NUEXCO

Monthly Report

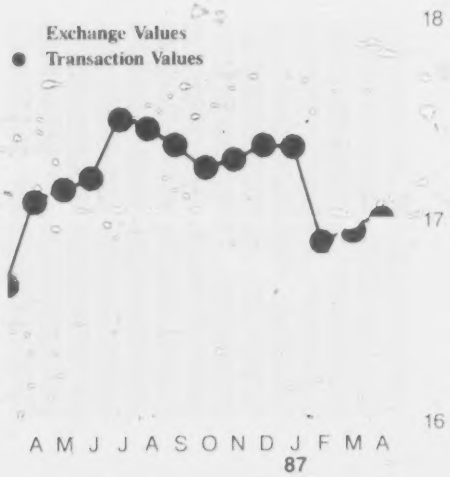
May 1987 Number 225

Five-Year Uranium Production Forecast

Japanese Utilities Plan New Nuclear Construction

First-Quarter South African Production Results

By-Product and Co-Product Uranium Resources and Production



NUEXCO

INTERNATIONAL HEADQUARTERS

Three Park Central, Suite 900 1515 Arapahoe Street Denver, Colorado 80202 USA
Telephone: (303) 893-4015 Telecopy: (303) 825-4821 Telex: 450202 (NUEXCO DVR)

CHAIRMAN — Oren L. Benton

DIRECTOR OF OPERATIONS — Transaction Services	James E. Lewis
DIRECTOR OF OPERATIONS — Information Services	J. Fred Lawrence

Manager of Fuel Transactions	Earl E. Hoellen, Jr.
Australia	George White, Jr.
Far East	Earl E. Hoellen, Jr.
North and South America	Earl E. Hoellen, Jr.
Southern Africa	James E. Vaughan
Europe	James E. Vaughan
Manager of Legal and Regulatory Affairs	Frederick J. Boyne
Manager of Property and Equity Transactions	Don A. Nichols
Manager of Information and Consulting	R. Gene Clark

INTERNATIONAL ADVISORY COMMITTEE

J. Robert (Bob) Wolcott
Chairman (USA)

T.J. (Tom) Barendregt
(The Netherlands)

Leland O. (Lee) Erdahl
(USA)

Lars Halle
(Sweden)

O.J.C. (John) Runnalls
(Canada)

George J. Stathakis
(USA)

James C.C. Stewart
(U.K.)

W. Bryan Webster
(USA)

NUEXCO

EXECUTIVE SUMMARY
REPORT 225
(All data as of April 30, 1987)

Exchange Value $17.00, unchanged

The **Exchange Value** is **$17.00** per pound U_3O_8, unchanged since last month.

UF_6 Value $48.00, unchanged

The **UF_6 Value** is **$48.00** per kilogram U as UF_6, unchanged since last month.

Transactions

Eight recent natural uranium sales are reported, involving **3.8 million** pounds equivalent U_3O_8. Six of the sales involved spot or near-term delivery, and five met the conditions for inclusion in the Transaction Value. Two transactions are reported involving low-enriched UF_6, totaling approximately 320,000 pounds equivalent U_3O_8.

Supply-Demand Ratio increased to 7.8:1

Active spot and near-term **uranium supply** amounts to **4.5 million** pounds U_3O_8 equivalent, up **one million pounds** since last month. Active spot and near-term **uranium demand** totals **575 thousand** pounds, down **1.2 million** pounds from last month. The spot and near-term **supply-demand ratio increased** to **7.8:1.**

Transaction Value $17.00, up $0.05

The **Transaction Value** is **$17.00** per pound U_3O_8, **up $0.05** since last month. The calculation includes 23 transactions involving a total of 4.9 million pounds U_3O_8 and equivalent UF_6, and covers a period of 3 months.

Loan Rate unchanged at 3%

The **Loan Rate** is **3 percent** per annum, unchanged.

Conversion Value $1.80, unchanged

The **Conversion Value** is **$1.80** per pound U as UF_6, **unchanged** since last month. Active secondary market supply for conversion services for delivery within three years totals **580** thousand pounds U as UF_6. Active demand totals **one million** pounds U as UF_6. **One** secondary market conversion transaction is reported.

SWU Value for delivery within one year: $77, unchanged

The **SWU Value** at .3 tails and for delivery within one year is **$77** per SWU, unchanged since last month. **Three** secondary market SWU transactions are reported

* * *

Analysis and Commentary

Nuexco's five-year uranium production forecast shows a slight increase in production under free market conditions, from 96 million pounds U_3O_8 in 1986 to approximately 98 million pounds by 1990. If US utilities were forced to use at least 50 percent US-origin uranium, US production would rise to about 18 million pounds in 1990, a 30-percent increase over the 1986 total of 13.8 million pounds U_3O_8. If that required percentage of US-origin consumption were increased to 75 percent, annual US output would rise to 25 million pounds by 1990.

Raw Materials

By-product or co-product uranium constitutes a significant part of the world uranium resource base. For example, nearly all of South Africa's uranium is produced as a by-product of gold mining. By-product uranium is mainly produced from quartz-pebble conglomerates (South Africa), and from phosphates (USA and USSR), but also may be produced from multi-mineral ores, black shales, mine water, lignites, and seawater. This article examines the spectrum of by-product uranium operations and technologies.

Japan

Several Japanese utilities may begin construction of as many as nine new nuclear units by the end of fiscal year 1988, totaling over 9,600 MWe of capacity, to meet forecast demand increases for electric power.

South Africa

First-quarter 1987 uranium output from South Africa's Chamber of Mines producers has declined 2.4 percent from the last quarter of 1986, totaling 2.71 million pounds U_3O_8. Substantial drops in production at Buffelsfontein, Harmony and Randfontein accounted for much of the decrease.

This Executive Summary may be reproduced for internal distribution

© NUEXCO 1987

NUEXCO REPORT 225 FIGURES OF THE MONTH (April 30, 1987)	This Month (Report 225)	Last Month (Report 224)	12 Months Ago (Report 213)
Exchange Value[1]	17.00	17.00	17.25
Transaction Value[1]	17.00	16.95	17.10
UF_6 Value[2]	48.00	48.00	48.50
Loan Rate[3]	3%	3%	5%
Conversion Value[4]	1.80	1.80	1.90
Near-Term Uranium Supply[5]	4.5	3.5	2.6
Near-Term Uranium Demand[6]	0.6	1.8	1.2
Near-Term Supply-Demand Ratio	7.8	1.9	2.1
Recent Uranium Sales:			
Number of Transactions[7]	10	10	6
Quantity of Material[8]	4.1	2.2	1.4
Nuexco SWU Value:[9]			
at 0.3 tails assay and delivery within one year	77	77	90
USDOE SWU Prices:			
USEC	119.00[10]	119.00[10]	125.00
AFC	153.00[12]	153.00[12]	153.00[12]
Requirements	157.00[12]	157.00[12]	157.00[12]
Incentive Price	90.00[13]	90.00	—
Market Value of Enriched UF_6[14,15]:			
2.5 w/o U^{235}	455	455	467
3.0 w/o U^{235}	582	582	598
3.5 w/o U^{235}	711	711	731
4.0 w/o U^{235}	842	842	866

[1]US $ per pound U_3O_8 equivalent.
[2]US $ per kilogram U as UF_6.
[3]Per annum.
[4]US $ per pound U as UF_6.
[5]Active inquiries to sell, for delivery within 12 months after contract signing (millions of pounds U_3O_8).
[6]Active inquiries to purchase, for delivery within 12 months after contract signing (millions of pounds U_3O_8).
[7]Uranium sales only; does not include loans, conversion, or SWU transactions.
[8]Millions of pounds U_3O_8 equivalent.
[9]US $ per SWU.
[10]Effective 10/1/86.
[11]Effective 10/1/85.
[12]Effective 10/1/84.
[13]Effective 10/1/86, for up to 30% of annual requirements.
[14]Calculated using the Nuexco Exchange Value, Conversion Value, and 0.30 percent tails assay. From 4/30/85 to 11/30/85, calculations used in the Nuexco SWU Value for DOE origin and delivery by the end of FY86. As of 12/31/85, calculations use the SWU Value for delivery within one year.
[15]US $ per KgU as UF_6, rounded to the nearest $.

INDEX TO LAST MONTH'S REPORT (224)

Section	Topic	Page
Analysis and Commentary	Uranium Import and Export Licensing in the USA	12
Essay	Australian Politics and Australian Uranium: A Commercial Anachronism	15
Nuclear Fuel Pricing		
	Natural Uranium and Conversion Pricing in March 1987	1
	Enriched Uranium and SWUs Pricing in March 1987	2

© NUEXCO 1987

CONTRACTING FOR URANIUM: AN ANALYSIS OF TRENDS IN TERMS AND CONDITIONS

NUEXCO is pleased to announce the availability of our report on contracting trends and practices within the uranium market. The report is a comprehensive analysis of historical trends and current practices in natural uranium contracting, including purchasing strategies of the various countries, and terms and conditions for new contracts and renegotiations. The report addresses the following areas in detail:

- Contract prices and pricing mechanisms
- Flexibilities in delivery schedules, quantities, location
- Termination clauses, force majeure issues, disputes
- Supply reliability
- Utility participation in production joint ventures
- Desired levels of strategic inventories
- General approach to contract negotiations or renegotiations
- Description of current uranium procurement practices
- Recommendations

For further information, please contact
Gene Clark or Treva King
at 303/893-4015.

NUEXCO

Three Park Central, Suite 900
1515 Arapahoe Street
Denver, Colorado 80202

Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 NUEXCO DVR

PROSPECTS FOR THE CANADIAN URANIUM INDUSTRY

By

O.J.C. Runnalls
Chairman, Centre for Nuclear Engineering
&
Professor of Energy Studies
University of Toronto, Toronto Canada

Presented
at the

Annual General Meeting
Canadian Institute of Mining and Metallurgy

Toronto, Ontario
May 5, 1987

©NUEXCO 1987

PROSPECTS FOR THE CANADIAN URANIUM INDUSTRY

By O.J.C. Runnalls
Chairman, Centre for Nuclear Engineering
&
Professor of Energy Studies
University of Toronto, Toronto, Canada

Dr. Runnalls, a resident of Toronto, Canada, worked for 20 years for Atomic Energy of Canada Ltd. until 1971, when he was appointed Senior Advisor, Uranium and Nuclear Energy in the Department of Energy, Mines and Resources in Ottawa. He also served for five years as Executive Vice President of Uranium Canada, Ltd. Since 1979, he has been associated with his alma mater, the University of Toronto, and presently is Chairman of the Centre for Nuclear Engineering. Dr. Runnalls is a member of Nuexco's International Advisory Committee.

This paper was prepared and presented by Dr. Runnalls for the Annual General Meeting of the Canadian Institute of Mining and Metallurgy at Toronto, Ontario on May 5, 1987.

Introduction

Since the phenomenon of nuclear fission was discovered in 1938, the utilization of uranium has grown substantially. Initially, the principal use for uranium was in the production of nuclear weapons. However, once civilian nuclear power reactors began to be built in the 1950s, an increasing fraction of uranium output was directed to the production of fuel elements for use in electricity generating stations.

The cumulative uranium production by those countries in the World Outside Centrally-Planned-Economies Areas (WOCA) during the period 1938-1985 exceeded 800,000 tonnes uranium. Some 60 percent of that was mined in the United States and Canada (Figure 1). In 1986, nearly 80 percent of WOCA output came from five countries, Canada, USA, South Africa, Australia, and Namibia, as shown in Table 1 and Figure 2.

During the past decade the world annual consumption of nuclear energy has more than tripled (Figure 3). As of December 31, 1986, the world total of nuclear power reactors had reached 394, with a total net capacity of 270 GWe[6]. The thermal output from nuclear power plants in 1985 exceeded 60 percent of the energy contained in all of the oil produced that year in the Middle East. Thus, nuclear power has already become an important component in the world energy supply picture.

Table 1

URANIUM PRODUCTION FROM WOCA COUNTRIES[2,3]

Country	Output (1,000 tonnes U) 1985	1986 (estimated)
Canada	10.9	11.7
United States	4.2	5.5
South Africa	4.8	4.7
Australia	3.3	4.2
Namibia	3.5	3.5
France	3.2	3.1
Niger	3.2	3.1
Gabon	0.9	0.9
Others	0.5	0.5
Total	34.5	37.2

Future Growth

Estimates of future growth of the industry have been published recently by the Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA) for WOCA countries[1,7]. Such estimates indicate that installed capacity of and electricity generation from nuclear plants could double by 2000. Longer range forecasts to 2025 using low and high projections reveal a large uncertainty by 2025 (Figure 4). The uncertainty alone in 2025 is nearly four times the 1986 installed capacity. There has been a tendency in recent years to discount future estimates for nuclear plant construction because of the inaccurate predictions of the past. During the 1970s forecasts of future capacity were over-optimistic but by the 1980's the earlier optimism had been modified appreciably.

Annual uranium requirements must rise to meet the growing numbers of reactors in operation and under construction. Requirements as estimated by the NEA and IAEA recently[1] are shown in Figure 5. The cumulative needs for the period 1985-2025 are plotted in Figure 6 for both high and low projections and for two reactor strategies, one employing light water reactors (LWRs) and the other if fast-breeder reactors (FBRs) are introduced in appreciable numbers in the 1990s. One concludes that with either strategy, severe stress will be placed on the world's uranium resources within a few decades.

© NUEXCO 1987

Figure 1

CUMULATIVE URANIUM PRODUCTION BY WOCA COUNTRIES 1938-1985 IN TONNES U [1,2]

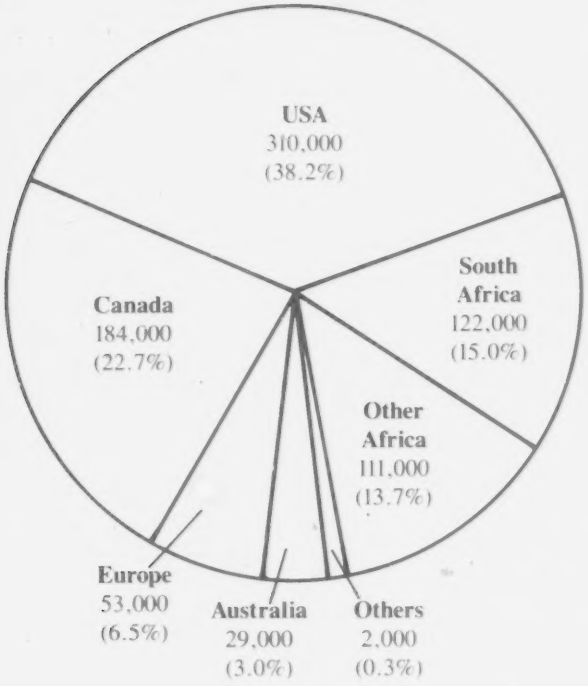
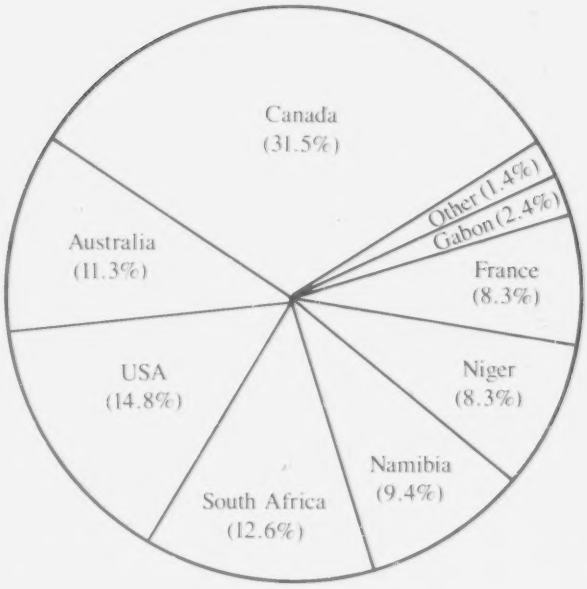


Figure 2

SHARES OF 1986 URANIUM PRODUCTION BETWEEN WOCA COUNTRIES [2,3]



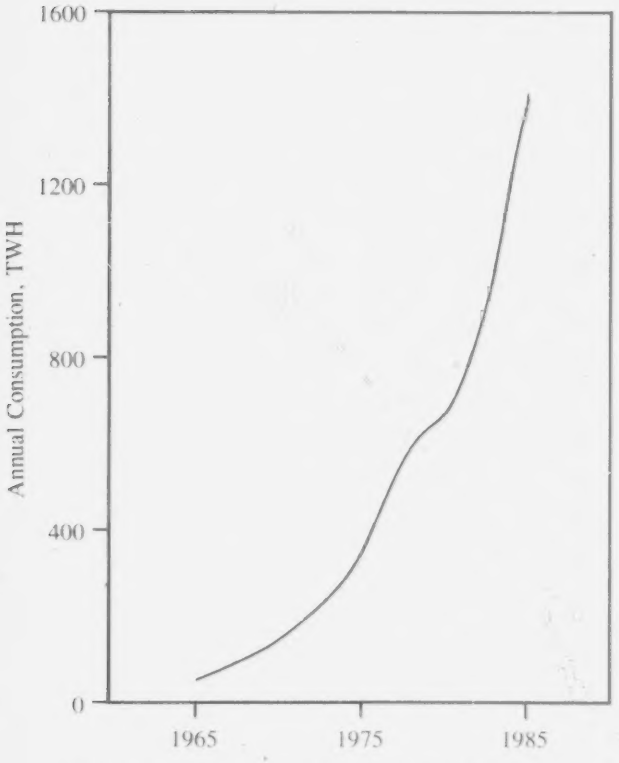


Figure 3. World Annual Consumption of Nuclear Energy[4,5,6]

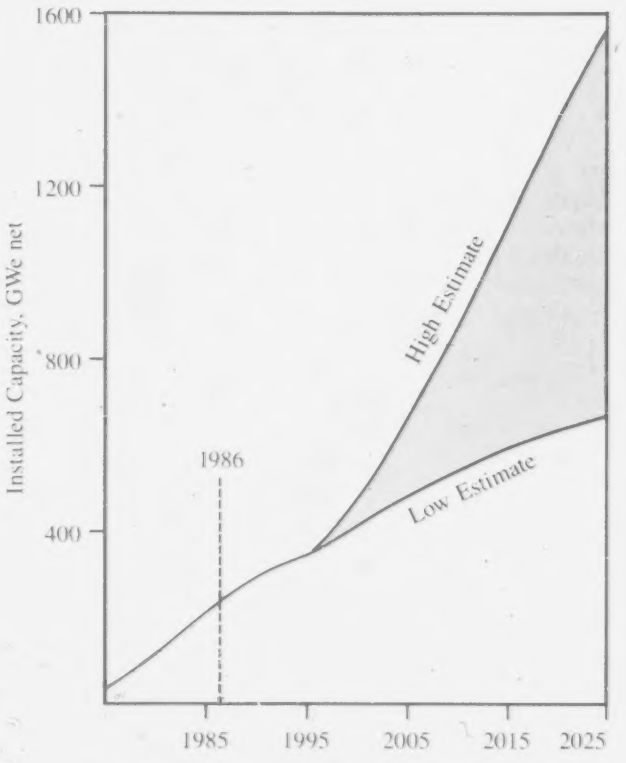


Figure 4. Nuclear Generating Capacity in WOCA Countries [1,7]

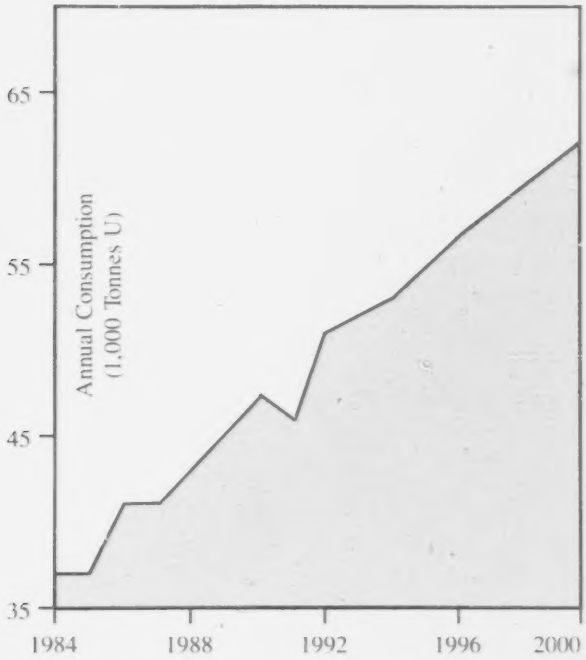
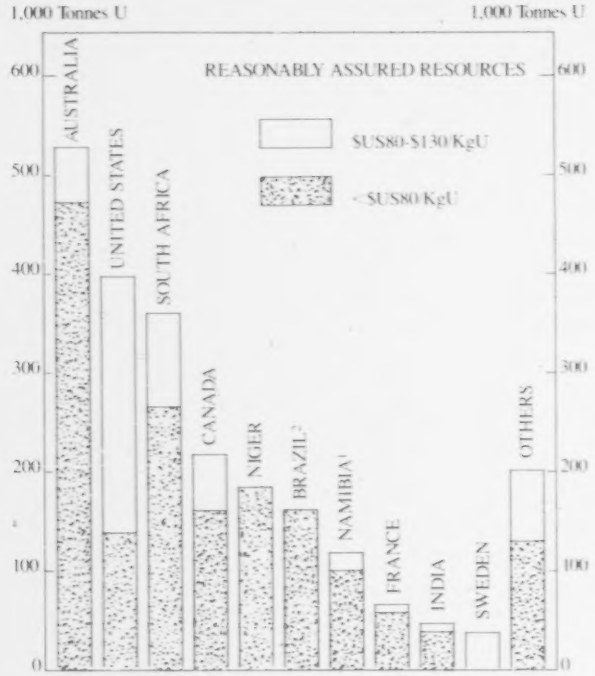


Figure 5. Annual Uranium Requirements for WOCA Countries[2]

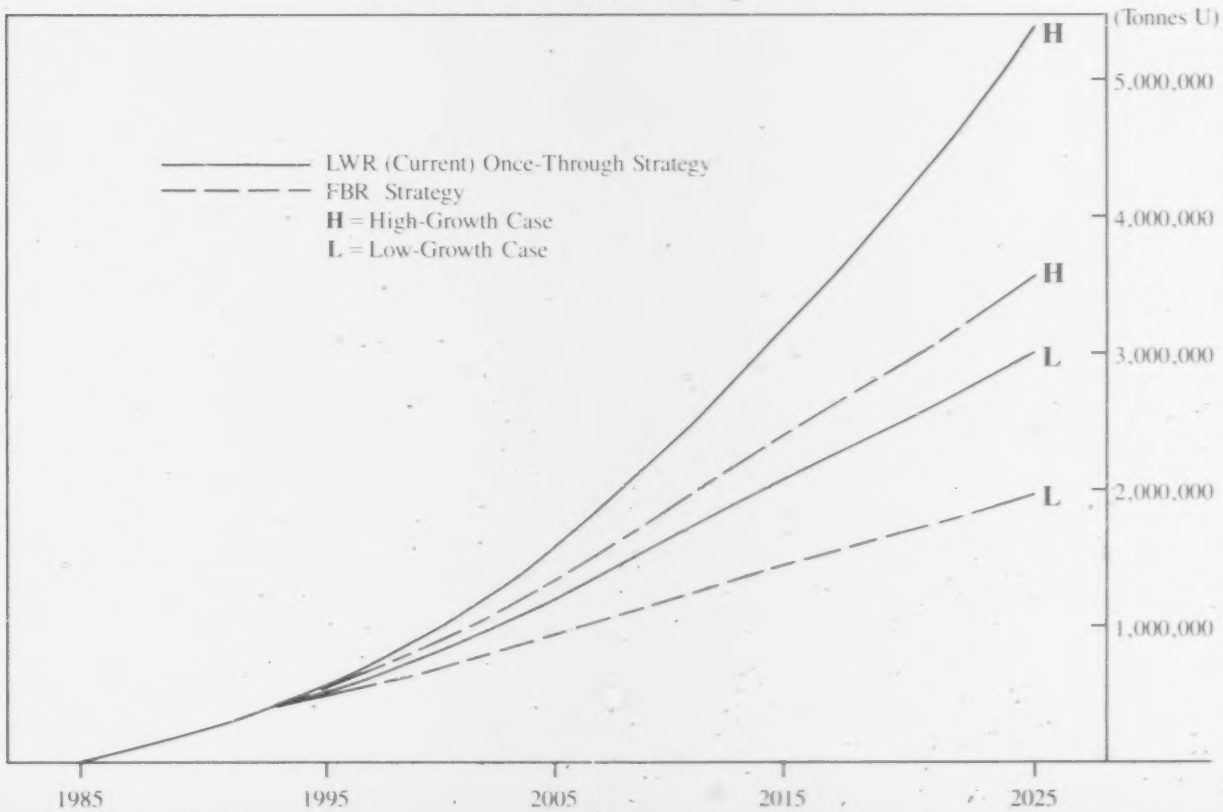


1. OECD (NEA)/IAEA: Uranium Resources, Production and Demand, Paris, 1983, adjusted for production and estimated production.
2. In situ resources.

Figure 7. Distribution of Uranium Resources among WOCA countries[1]

Figure 6

ILLUSTRATIVE LONG-TERM PROJECTIONS OF RANGE OF CUMULATIVE REACTOR-RELATED URANIUM REQUIREMENTS[1]



Uranium Resources and Production

According to the NEA/IAEA[1], Reasonably Assured Resources in WOCA countries recoverable for up to $US 130 per kilogram U, some three times the current spot market price, total 2.3 x 10^6 tonnes U (Figure 7). The foreseen rise in uranium consumption has led analysts such as Frisch[8] to predict that the exhaustion of proven uranium reserves could spread contagiously to the whole world between 2010 and 2015. Such projections run counter to the widely-held belief in the nuclear industry that the current surfeit of low-priced uranium will persist for the foreseeable future.

It is now appreciated that for most of the past two decades WOCA production has considerably exceeded requirements, as shown in Figure 8. That situation has been reversed for the past two years. Nonetheless, enough stockpiles have been accumulated since the mid-1960s to provide fuel for existing reactors for perhaps the next three or four years[1]. The presence of such inventories overhanging the market coupled with the conviction of nuclear power plant owners that uranium will be available in abundance for the long term have resulted in a substantial drop in the world market price, which had peaked in 1979. The spot market price, for example, decreased by more than three-fold between 1979 and 1987 when measured in constant dollars. Such downward pressure on prices has had a profound effect on the uranium production industry, particularly that in the USA. Output from US mines dropped by four-fold between 1980 and 1985 as many high cost mines were forced to close in the face of falling prices.

Meanwhile, mining from the rich, newly-discovered Canadian deposits in the Athabasca Sandstone region of northern Saskatchewan had grown, so that Canada became the world's largest uranium producer beginning in 1984. Strong pressures have been exerted by the US uranium industry and by sympathetic politicians from the mining states in the midwestern USA to limit imports of uranium into the country. An important decision is expected soon from the US Tenth Circuit Court of Appeals in the Uranium Producers of America vs. US Department of Energy (DOE) lawsuit, which was filed, among other reasons, to prevent non-US-origin uranium from being processed in DOE enrichment plants until it can be demonstrated that the domestic uranium industry has recovered from its current non-viable state. Since the USA consumes about 30 percent of the uranium produced by WOCA countries, any import restrictions into that country would have a negative impact on outside producers such as Canada. One of the likely consequences would be the development of a two-tiered pricing structure with domestic American production commanding a higher price within the USA.

The possibility of a three-tiered structure exists as well because of the promulgation of the Anti-Apartheid Act of 1986 by the US Congress. One of the effects of the passing of this legislation, and of possible additional restrictive actions by members of the US Congress, will be to stop all imports of uranium of South African origin into the USA. In a world of few exporters these various moves by the USA could have an appreciable effect on the world market.

There has been some speculation that the Chernobyl nuclear reactor accident of April 1986 might have a large impact on annual uranium consumption. However, few countries have modified significantly their reactor programs in the months following the accident, and it now seems that any reduction in uranium consumption will be of only second-order effect, perhaps up to 5 percent overall.

Other factors leading to lower uranium consumption are the development of higher burn-up fuel, improved fuel management, and new fuel designs. Because of such developments, uranium demand in the USA, for example, could show a net decrease of some 6-7 percent by 2000. The resulting decrease in consumption is likely to be countered, however, by an increase resulting from increasing capacity factors in existing generating stations[9].

As mentioned earlier, a conviction has developed amongst WOCA countries during the past few years that uranium will continue to be available in abundance. This is reflected in appreciable reductions in exploration budgets, as illustrated in Figure 9. One could conclude that the stage is being set for a resurgence of the uranium supply industry in the 1990s to meet possible shortages.

What is often not appreciated by nuclear power plant owners is that the lead-times required to find and bring into production new uranium deposits can be longer than those needed to initiate, construct and commission a new nuclear power facility. The history of the development of the rich Key Lake mine in northern Saskatchewan is a case in point where even in a geologically-promising area in a stable and friendly country, the elapsed time between launching exploration, discovering a commercial uranium deposit, and achieving first output was fifteen years[10].

According to the NEA/IAEA, it is possible that within ten years additional production requirements, beyond those exisitng and committed and those planned and prospective, could be required (Figure 10). Given such estimates, it is timely that the Cigar Lake Mining Corporation should be moving ahead positively to bring into production its extremely rich uranium deposit in northern Saskatchewan by 1993[11].

© NUEXCO 1987

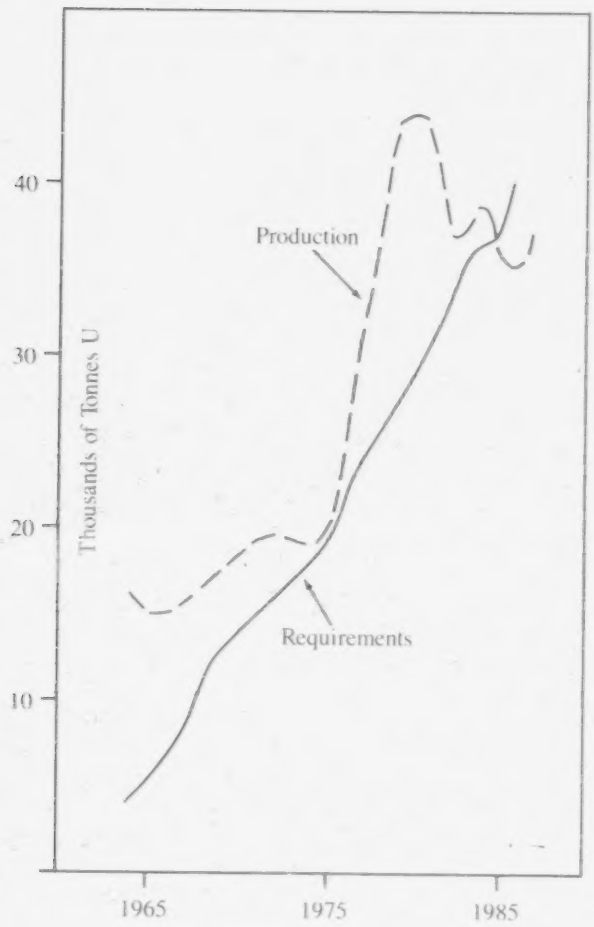


Figure 8. WOCA Uranium Production and Requirements, 1964-1986[1,2]

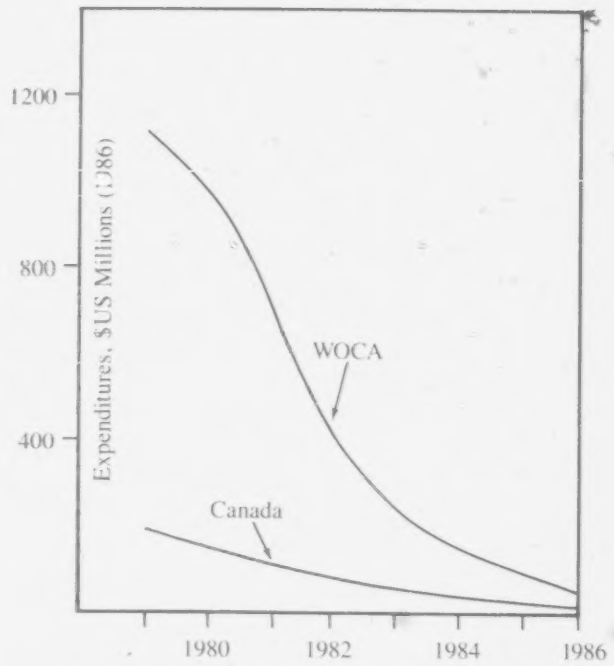


Figure 9. WOCA Uranium Exploration Expenditures[1,3]

The Canadian Uranium Industry

Meanwhile, in the midst of the currently uncertain market, the Canadian uranium mining industry has maintained a profitable position. Canada's five primary producers reported a total output in 1986 of 11,720 tonnes U[3].

Although the Elliot Lake deposits in northern Ontario are relatively low in grade, they are massive in nature and the two companies mining in the area, Denison Mines Limited and Rio Algom Limited, have operated profitably there for many years. Both producers benefit from long-term supply contracts with domestic utilities and foreign customers. Some of these purchase commitments extend well into the next century.

Uranium shipments from Ontario producers were valued at $476 million in 1986, somewhat higher than the $447 million of product shipped from Saskatchewan[3]. The output from Ontario, however, was lower than that from Saskatchewan, being 43 percent of total production.

There are three operations in northern Saskatchewan, as follows:

1. Key Lake Joint Venture — owned by Saskatchewan Mining Development Corpration (SMDC[1], 50%), Uranerz Exploration and Mining Limited (UEM[2], 33.3%), and Eldor Resources Limited (16.7%).

2. Rabbit Lake and nearby properties — owned by Eldorado Resources Limited.

3. Cluff Mining — owned by Amok Ltd.[3] (80%), and SMDC (20%).

Eldor Resources Limited and Eldorado Resources Limited are both subsidiaries of Eldorado Nuclear Limited, a federally-owned crown corporation. Eldorado Resources

[1]SMDC is a crown corporation owned by the province of Saskatchewan.
[2]UEM is a subsidiary of Uranerzbergbau, Bonn, West Germany.
[3]Amok is owned entirely by French interests.

©NUEXCO 1987

operates a uranium refinery at Blind River, Ontario, and a chemical conversion plant at Port Hope, Ontario to produce ceramic-grade uranium dioxide (UO_2) powder for CANDU reactor fuel fabrication, and uranium hexafluoride (UF_6) for export abroad to uranium isotope enrichment facilities.

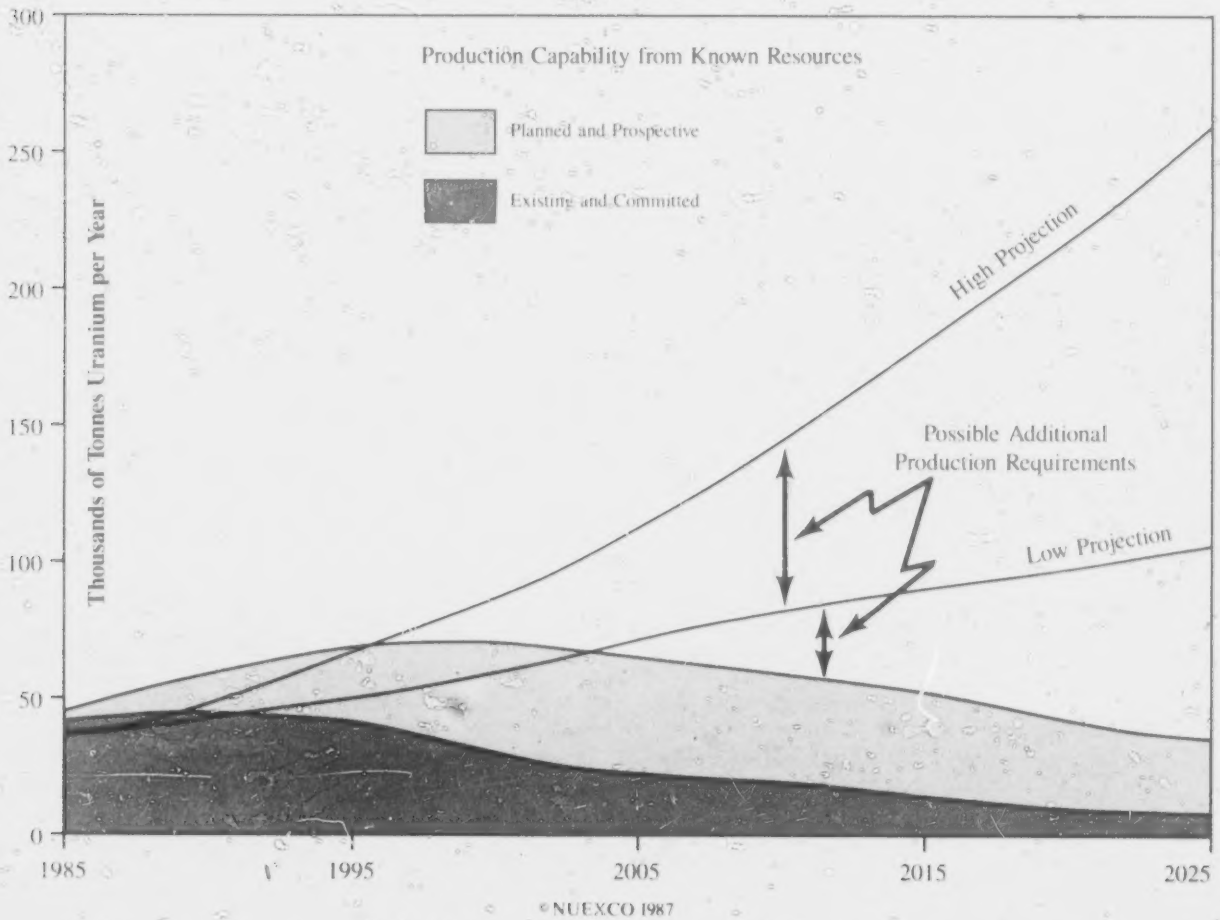
The federal government issued a policy in 1974 stating that unless a specific exemption was issued by the regulatory agency, the Atomic Energy Control Board, uranium would have to be upgraded to the most advanced form possible in Canada before export approval would be granted[12]. In effect, this meant that uranium concentrates would have to be converted to UF_6 in the only facility available, Eldorado's, prior to export. The USA recently took issue with this upgrading policy, after it had been in operation for more than a decade, and filed a formal protest under the General Agreement on Tariffs and Trade, (GATT)[13]. The charge is that the policy is inconsistent with Article XI of GATT, which forbids export restrictions.

Eldorado's problems were further compounded in late 1986 when the Canadian government announced as part of its anti-apartheid measures that no uranium of South African origin in any form would be allowed into Canada, even if it was merely in transit for processing and re-export by Eldorado.

The federal government's clear intention after nearly three years of sales efforts is still to dispose of Eldorado Nuclear Limited to outside investors. To facilitate this process, the government of Canada transferred the ownership of its Eldorado shares in January, 1983 to another crown-owned firm, the Canada Development Investment Corporation[14], which currently is engaged in developing possibilities for Eldorado's sale.

Figure 10

WOCA URANIUM PRODUCTION CAPABILITY AND REACTOR-RELATED REQUIREMENTS, 1985-2025[2]



©NUEXCO 1987

Future Prospects

The deposits being exploited in Saskatchewan are some of the world's richest. Many are near-surface and can be recovered using open-pit techniques. The Cigar Lake deposit, however, is located at a depth of some 430 metres between the overlying sandstone and the underlying metamorphic gneisses. Fortunately, the ore is very rich. The total ore reserve estimate for the deposit stands at 150,000 tonnes U[11]. This is sub-divided between two regions, the main pod zone and the western extension. Reserves in the former mineralized area total 110,000 tonnes U averaging 12 percent uranium. The western extension contains inferred reserves of 40,000 tonnes U in ore averaging 4 percent uranium[11]. By comparison, the Elliot Lake ores currently being mined from a depth of some 1,000 metres assay at about 0.1 percent uranium.

Other ore discoveries with commercial potential have been found in Saskatchewan at Midwest Lake, Dawn Lake, McLean Lake, and Maurice Bay. Promising deposits have also been delineated at Lone Gull in the Northwest Territories and Blizzard in British Columbia. Development of these ore-bodies is likely to be delayed, however, until the mid-1990s or later because of current unfavourable market conditions.

The potential for future discovery is high, particularly in the western part of the country where most of the current exploration effort is being expended. Many countries with few indigenous uranium resources and growing nuclear programs are continuing to invest there in the search for new deposits.

One could predict that for many decades into the future, given the promising prospects for discovery and development as well as the present appreciable production base, Canada should continue to be an important uranium producer. The domestic nuclear reactor program will have first priority on any output. Currently that requirement is only about 15 percent of the total, however, so large tonnages are available for export. It is probable, therefore, that Canada will remain as an important supplier into the world market for many years to come.

References

1. *Uranium — Resources, Production and Demand*, OECD Nuclear Energy Agency and the International Atomic Energy Agency, Paris, 1986.
2. Unpublished data, *Uranium Institute*, London, January, 1987.
3. Whillans, R.T., "Uranium", *Canadian Mining Journal*, in press, March, 1987.
4. *Annual BP Statistical Reviews of World Energy*, British Petroleum Company, London, England, June, 1986 (and earlier).
5. *Nucleonics Week*, McGraw-Hill Inc., New York, Vol. 28, February 5, 1987: 9.
6. *IAEA Newsbriefs*, International Atomic Energy Agency, Vienna, Vol. 2, No. 2, February 10, 1987: 2.
7. *Summary of Nuclear Power and Fuel Cycle Data in OECD Member Countries*, OECD, Paris, April, 1986.
8. Frisch, J.R., *Future Stresses for Energy Resources*, World Energy Conference Conservation Commission, 13th Congress of the World Energy Conference, Cannes, France, October 11, 1986.
9. *Nuclear Fuel*, McGraw-Hill Inc., New York, Vol. 11, No. 19, September 22, 1986: 7.
10. Runnalls, O.J.C., *Key Lake: A Model of Canadian Development*, Proceedings, Deutsches Atomforum Winter Meeting, Bonn, Federal Republic of Germany, January 27-28, 1987.
11. Peebles, G.A., and J.M. Potier, *Mining the Cigar Lake Uranium Deposit*, Uranium Institute Eleventh Annual Symposium, London, September 2-4, 1986.
12. MacDonald, Hon. D.S., *Statement on Canada's Uranium Policy*, Ottawa, Ontario, September 5, 1974.
13. *Nuclear Fuel*, McGraw-Hill Inc., New York, Vol. 12, No. 1, January 12, 1987: 1.
14. Eldorado Nuclear Limited, Ottawa, Ontario, *Annual Report*, 1983: 9.

©NUEXCO 1987

NUEXCO

MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

May 1987 No. 225

R. WESLEY MILLER, *EDITOR* CHARLES B. LEWIS, *ASSISTANT EDITOR*

PRICING
Natural Uranium and Conversion 1
Enriched Uranium and SWUs 2

CURRENT MARKET DATA
Nuexco Market Values 3
Nuexco Market Values Expressed in Selected Currencies 4
Recent Transactions 6
Supply and Demand Tables 8

ANALYSIS AND COMMENTARY
Five-Year World Production Forecast 13

RECENT DEVELOPMENTS
Japan 19
South Africa 20

RAW MATERIALS
By-Product and Co-Product Uranium Resources and Production 21

HISTORICAL MARKET DATA
Graph of Exchange Value and Transaction Value 29
Historical Exchange Values and Transaction Values 30
Historical Conversion Values and UF_6 Values 31
Graph of World Uranium Production 32
US Uranium Marketing Activities Statistics 33
Volume and Price of Uranium Deliveries to the European Community 34

GOVERNMENT STATISTICS
Australia 35
Canada 36
South Africa 37
United States 38

NOTICE

This Report is prepared especially for Subscribers and is furnished to them for their use only. Except for internal use by Subscribers, no part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior written permission of Nuexco. Neither this Report, nor copies of any portion thereof, may be lent, sold or given to non-Subscribers.

The information in this Report was gathered from sources Nuexco believes to be accurate. However, Nuexco makes no warranty, express or implied, and assumes no legal liability or responsibility for the accuracy, completeness or usefulness of any information contained herein. © 1987 Nuexco Services Ltd. ISSN 0742-4582

NUEXCO

PRICING

NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of April 30, 1987)

The **Exchange Value** is **$17.00** per pound U_3O_8, unchanged since last month. **Active supply** of natural uranium (concentrates and UF_6) for spot or near-term delivery totals **4,495,000** pounds U_3O_8 equivalent, up one million pounds since last month. The corresponding figure for **active demand** is **575,000** pounds, down 1,225,000 pounds. The spot and near-term **supply-demand ratio** increased to **7.8 to 1.**

The *Current Market Data* section of this Report lists seven natural uranium concentrate sales, and one sale of natural UF_6, totaling 3.8 million pounds U_3O_8 equivalent. Two transactions involving low-enriched UF_6 are reported, totaling 300,000 pounds equivalent U_3O_8. US-origin uranium is commanding a premium (relative to the Exchange Value) of $1.50 per pound U_3O_8 (unchanged) in the form of concentrates, and $3.00 per kilogram U (down $0.50) in the form of UF_6.

The **Transaction Value** is **$17.00** per pound U_3O_8, up $0.05 since last month. The calculation extends over a 3-month period and includes 23 transactions involving 4.9 million pounds equivalent U_3O_8.

The **UF_6 Value** is **$48.00** per kilogram U in UF_6, unchanged since last month. There remains a substantial spread between prices that discretionary UF_6 buyers are willing to pay and those that sellers will accept.

The **Conversion Value** is **$1.80** per pound U in UF_6, unchanged since last month. Active supply of secondary market conversion services for delivery within three years totals 580 thousand pounds U as UF_6. Active demand totals one million pounds U as UF_6. One secondary market conversion transaction is reported.

The **Loan Rate** is **3 percent** per annum, unchanged.

* * *

The Exchange Value remained at $17.00 this month, as several large spot transactions were concluded near this price, both by US and European utilities. These sales have removed much of the firm demand from the market, leaving mainly discretionary buyers. Supply, however, increased as substantial new quantities were made available. The reduction in demand and the coincident increase in supply have resulted in an increase in the supply-demand ratio since last month. Two long-term sales to US utilities totaled over 2.5 million pounds, while two other buyers concluded large spot purchases. Altogether, more than 4 million pounds U_3O_8 equivalent were sold during April.

The limitations and uncertainties caused by the Anti-Apartheid Act of 1986 in the USA, the still unresolved US Producers vs. DOE lawsuit, the Canadian upgrading policy, and non-proliferation restrictions on end use have fragmented the uranium market. Several factors point to origin and physical location as the prime considerations in price determination:

1. Substantial premiums for US-origin;

2. Smaller, occasional premiums for central African and other origins without certain types of end-use restrictions;

3. Frequent discounts for southern African-origin uranium;

4. The increasing desire by some US utilities to buy uranium that can be certified to have been produced in the USA, rather than US-origin material obtained by means of a flag swap.

Historically, swaps have been used to reduce or eliminate transportation costs and to expedite transactions. The primary reasons behind the increase in swap activity over the past year have been the wish to avoid certain national origins, the desire to profit from premiums associated with other origins, and the need or desire to circumvent prohibitions on physical delivery of specific origins or forms.

Uncertainties surrounding the position of the US Nuclear Regulatory Commission (NRC) in approving swaps of material being held at different licensee facilities lately have served to undermine the potential viability of swap transactions. Until recently, the NRC has essentially implied consent over swaps that may or may not have fallen under NRC jurisdiction. That position has changed somewhat, in that the NRC now appears to be withholding judgment, rendering neither approval nor disapproval.

De jure sanctions against importation of southern African uranium into the USA, and similar *de facto* sanctions imposed by other countries have constrained virtually all buyers in North America and some in Europe from taking delivery of southern African material. However, substantial quantities of discount-priced uranium from southern Africa have been made available selectively to those few buyers able to take advantage of that origin, either by accepting that material directly or by accepting material swapped for the southern African-origin material. Although nominal transaction prices may be near Exchange Value, extended payment terms and other inducements tend to reduce substantially the *effective* price of such material. One transaction reported this month involves a large quantity of southern African U_3O_8

©NUEXCO 1987

bought through such an arrangement, and considerably more material may be available.

In addition to one spot sale of US-origin uranium to a US utility, two long-term sales of US-origin also were concluded in April, with prices related to future market values. The premium (relative to the Exchange Value) for US-origin concentrates is unchanged at $1.50. In recent months, swaps have been the primary vehicle by which US-origin uranium is procured, and the premium (i.e. the incremental price commanded by US-origin material in transactions where the buyer restricts the acceptable origin to US) plus the Exchange Value has been less than the prices offered by US producers for their US-origin material.

Although US producers had been holding back from the market in anticipation that the Tenth Circuit Court of Appeals would quickly resolve the US Producers vs. DOE lawsuit, financial pressures have forced some US producers to compete more aggressively for available market opportunities. Producers' asking prices have declined recently, in some cases to a level approximately equal to the sum of the Exchange Value and the US premium. A resolution favorable to US producers still would likely cause a substantial increase in prices for US-origin, but until then, the short-term outlook for the US-origin premium is unclear. Much of the demand for US-origin for spot or near-term delivery has been filled over the past year, and the intense motivation by a number of utilities to procure US-origin has begun to subside. Many utilities have optimized origin status within their inventories through swaps and, consequently, feel little immediate pressure to add more US-origin uranium to their stocks.

Canadian sellers have not noticeably altered their asking prices in order to make spot sales. One large sale was made this month by a Canadian producer to a US utility. Although the contract price reportedly was close to the Exchange Value, the *effective* price, reflecting payment terms and conditions, was well below the contract price.

The UF_6 Value remained unchanged this month, at $48.00 per kgU as UF_6. One transaction reported this month involved natural UF_6, and two sales of low-enriched UF_6 are reported; altogether these transactions total less than 500,000 pounds U_3O_8 equivalent. These sales have removed some UF_6 demand from the market. Canadian sellers' aggressiveness in pursuit of available sales opportunities has lessened in recent months. At present, US-origin UF_6 appears to be relatively more abundant than US-origin U_3O_8, causing a slight decline in the premium (relative to the UF_6 Value) for US-origin UF_6 to $3.00 per kgU, down $0.50 since last month.

* * *

The Loan Value remained unchanged this month, at three percent. No loan transactions are reported. Both demand and activity in the market for loans have been small, often due to the security requirements imposed by most lenders.

* * *

The Conversion Value is unchanged since last month at $1.80. One small secondary market conversion sale is reported, but the secondary market for conversion services remains relatively inactive. Although demand has increased since last month, it remains highly discretionary.

ENRICHED URANIUM AND SWUS

The SWU Value remained at $77 per SWU this month. Three SWU transactions, totaling less than 100 thousand SWU, are reported in the *Current Market Data* section of the Report. There is some uncertainty in the SWU market, resulting from DOE's apparent willingness to adjust the enrichments of enriched product inventories to conform with the levels required by SWU buyers. Such a policy would reduce or eliminate the need for virgin or upgrade SWU, and tend to reduce or eliminate the premium that such upgrade SWU have commanded.

There is speculation that substantial additional SWU supplies, some in the form of enriched product, may soon be available from sources that have not previously been sellers. Thus, while the market has not yet been affected, the prospect of additional SWU supplies becoming available could lead to downward pressure on prices.

Separately, DOE has announced that its new SWU price under the Utility Services contract for FY88 (effective October 1, 1987) is $117 per SWU.

© NUEXCO 1987

NUEXCO

CURRENT MARKET DATA

April 30, 1987	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE	**$17.00**/lb. U_3O_8	4,495	575
UF_6 VALUE	**$48.00**/kgU		
CONVERSION VALUE	**$1.80**/lb. U as UF_6	580	1,000
SWU VALUE 0.3 tails assay: delivery within one year	$77/SWU		
LOAN RATE	3%/annum	1,000	500

	$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
TRANSACTION VALUE	**17.00**	4.9	23	3

[1]Supply and demand tables in *Current Market Data* section of this Report detail the numbers for each category.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Value** represents Nuexco's judgment of the price at which transactions for the sale of significant quantities of SWUs of stated origin for delivery in the specified time period could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three-month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

   The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of the Conversion Value, Nuexco does not consider transportation charges other than those customarily provided by primary suppliers of conversion services.
4. The prices of conversion services or SWUs delivered under long-term contracts with primary suppliers are not considered in the determination of either the Conversion Value or SWU Value.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight-percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

©NUEXCO 1987

CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (Apr 30, 1987)	Last Month (Mar 31, 1987)	12 Months Ago (Apr 30, 1986)	This Month (Apr 30, 1987)	Last Month (Mar 31, 1987)	12 Months Ago (Apr 30, 1986)
Australia (dollar)	26.15	24.16	23.31	67.97	62.82	60.60
Belgium (comm. franc)	631.50	633.86	762.95	1,642	1,648	1,983
Canada (dollar)	22.73	22.22	23.79	59.09	57.77	61.84
EEC (ecu)	14.72	14.80	17.44	38.26	38.47	45.35
Finland (markka)	74.46	75.35	84.98	193.59	195.91	220.92
France (franc)	101.49	101.86	119.46	263.86	264.81	310.57
FRG (mark)	30.45	30.54	37.51	79.16	79.39	97.51
Italy (lira)	21,778	21,862	25,723	56,618	56,837	66,875
Japan (yen)	2,366	2,484	2,893	6,152	6,457	7,521
Netherlands (guilder)	34.39	34.57	42.28	89.41	89.87	109.92
South Africa (rand)	34.03	34.07	35.46	88.48	88.57	92.18
Spain (peseta)	2,140	2,157	2,384	5,563	5,607	6,198
Sweden (krona)	106.65	107.32	120.88	277.27	279.02	314.27
Switzerland (franc)	24.96	25.48	31.37	64.88	66.24	81.55
UK (pound)	10.24	10.58	11.14	26.62	27.49	28.97
US (dollar)	17.00	17.00	17.25	44.20	44.20	44.85

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 in Concentrates			per kg. U in Concentrates		
	This Month (Apr 30, 1987)	Last Month (Mar 31, 1987)	12 Months Ago (Apr 30, 1986)	This Month (Apr 30, 1987)	Last Month (Mar 31, 1987)	12 Months Ago (Apr 30, 1986)
Australia (dollar)	26.15	24.09	23.11	67.97	62.64	60.08
Belgium (comm. franc)	631.50	631.99	756.30	1,642	1,643	1,966
Canada (dollar)	22.73	22.15	23.58	59.09	57.60	61.30
EEC (ecu)	14.72	14.76	17.29	38.26	38.36	44.56
Finland (markka)	74.46	75.13	84.24	193.59	195.33	219.00
France (franc)	101.49	101.56	118.42	263.86	264.03	307.87
FRG (mark)	30.45	30.45	37.18	79.16	79.16	96.66
Italy (lira)	21,778	21,798	25,500	56,618	56,670	66,293
Japan (yen)	2,366	2,476	2,868	6,152	6,438	7,455
Netherlands (guilder)	34.39	34.47	41.91	89.41	89.60	108.96
South Africa (rand)	34.03	33.97	35.15	88.48	88.31	91.38
Spain (peseta)	2,140	2,150	2,363	5,563	5,590	6,144
Sweden (krona)	106.65	107.01	119.83	277.27	278.20	311.54
Switzerland (franc)	24.96	25.40	31.10	64.88	66.05	80.84
UK (pound)	10.24	10.54	11.05	26.62	27.41	28.72
US (dollar)	17.00	16.95	17.10	44.20	44.07	44.46

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on April 30, 1987.

©NUEXCO 1987

NUEXCO

CURRENT MARKET DATA

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U as UF_6			per kg. U as UF_6		
	This Month (Apr 30, 1987)	Last Month (Mar 31, 1987)	12 Months Ago (Apr 30, 1986)	This Month (Apr 30, 1987)	Last Month (Mar 31, 1987)	12 Months Ago (Apr 30, 1986)
Australia (dollar)	2.77	2.56	2.57	6.10	5.64	5.66
Belgium (comm. franc)	66.86	67.11	84.03	147.41	147.96	185.26
Canada (dollar)	2.41	2.35	2.62	5.31	5.19	5.78
EEC (ecu)	1.56	1.57	1.92	3.44	3.45	4.24
Finland (markka)	7.88	7.98	9.36	17.38	17.59	20.63
France (franc)	10.75	10.78	13.16	23.69	23.78	29.01
FRG (mark)	3.22	3.23	4.13	7.11	7.13	9.11
Italy (lira)	2,306	2,315	2,833	5,084	5,103	6,246
Japan (yen)	250.56	262.97	318.63	552.38	579.74	702.46
Netherlands (guilder)	3.64	3.66	4.66	8.03	8.07	10.27
South Africa (rand)	3.60	3.61	3.91	7.94	7.95	8.61
Spain (peseta)	226.56	228.34	262.58	499.47	503.40	578.88
Sweden (krona)	11.29	11.36	13.31	24.90	25.05	29.35
Switzerland (franc)	2.64	2.70	3.46	5.83	5.95	7.62
UK (pound)	1.08	1.12	1.23	2.39	2.47	2.71
US (dollar)	1.80	1.80	1.90	3.97	3.97	4.19

SWU VALUE AND UF_6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	SWU VALUE delivery within one year (April 30, 1987)	UF_6 Value per kg.U in UF_6 This Month (April 30, 1987)	UF_6 Value per kg.U in UF_6 Last Month (March 31, 1987)
Australia (dollar)	118.43	73.82	68.23
Belgium (comm. franc)	2,860	1,783	1,790
Canada (dollar)	102.95	64.17	62.73
EEC (ecu)	66.67	41.55	41.78
Finland (markka)	337.28	210.24	212.76
France (franc)	459.70	286.56	287.59
FRG (mark)	137.92	85.97	86.22
Italy (lira)	98,642	61,491	61,728
Japan (yen)	10,718	6,682	7,012
Netherlands (guilder)	155.78	97.10	97.60
South Africa (rand)	154.15	96.09	96.19
Spain (peseta)	9,692	6,042	6,089
Sweden (krona)	483.06	301.12	303.03
Switzerland (franc)	113.04	70.46	71.94
UK (pound)	46.37	28.90	29.86
US (dollar)	77.00	48.00	48.00

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on April 30, 1987.

© NUEXCO 1987

RECENT TRANSACTIONS[1]

Uranium Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price as Percent of Current Exchange or UF_6 Value	Seller	Buyer	Remarks
4009	1987	101-300	101	Utility	Trader	
4017	1987	101-300	105	Trader	Utility	US-origin.
4020	1987	less than 50	102	R[5]	Producer	
4021	1990-94	101-300	see Remarks	Producer	Utility	US-origin. Price related to market.
4024A	1987	50-100	R[5]	Trader	Utility	Low-enriched UF_6.
4034	1989-95	1,501-3,000	see Remarks	Producer	Utility	US-origin. Price related to market.
4037	1987	301-600	99	Trader	Utility	
4038A	1988	101-300	R[5]	Trader	Utility	Low-enriched UF_6.
4039	1987	301-600	R[5]	Producer	Utility	
4040	1988	101-300	110	Trader	Utility	UF_6.

[1]Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2]If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.
[3]Price are usually normalized to 0.30% tails assay.
[4]Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g. X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.
[5]The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

© NUEXCO 1987

NUEXCO

CURRENT MARKET DATA

Conversion Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U equivalent)	Approximate Price as Percent of Current C.V.	Seller	Buyer	Remarks
4036	1987	less than 50	94	Trader	R[5]	

Enrichment Services
Secondary Market Sales

Nuexco Transaction Number	Delivery Period	Approximate Quantity[2] (thousands of SWUs)	Approximate Price[3] as Percent of Current SWU Value[4]	Seller	Buyer	SWU Origin	Remarks
4023	1987	less than 50	100	Utility	Trader	Eurodif	
4024A*	1987	less than 50	R[5]	Trader	Utility	USSR	Low-enriched UF_6.
4038B	1988	50-100	R[5]	Trader	Utility		Low-enriched UF_6.

[1]Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2]If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.
[3]Price are usually normalized to 0.30% tails assay.
[4]Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts (e.g. X dollars less than DOE's USEC base price at time of delivery), the percentage refers to the ratio of the *discounts*, not the ratio of the prices.
[5]The notation *R* means that Nuexco either does not know, or that Nuexco has restricted that information to protect client confidentiality.

© NUEXCO 1987

URANIUM SUPPLY
(April 30, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2335	420	—	
2740	250	—	
2764*	500	—	UF_6
2893A	720	—	UF_6
2933	300	300 per year	1988-90
2973	15	—	
2989	40	—	
3023	500	500	UF_6
3121*	1,000	—	
3129	500	1,000	
3135*	200	—	
3166	50	—	
2263	—	400 per year	1989 on
2781*	—	400 per year	1988-95
2996	—	500 per year	1988-90
3123*	—	2,000	1988
3171	—	200 per year	1988-92
3244*	—	300 per year	1988-93
TOTAL:	4,495		
INACTIVE			
2297	100	100 per year	1988-89
2389	300	—	
2967*	1,000	—	
3168	50	100 per year	1988-92
2336	—	200 per year	1988-94
2625	—	500 per year	1988 on
2981	—	600 per year	1988-91
3128	—	100	1988 on
TOTAL:	1,450		

*New or revised since last month.
[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 3221.

© NUEXCO 1987

NUEXCO

CURRENT MARKET DATA

URANIUM DEMAND
(April 30, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
2890	175	—	
2984*	260	—	U_3O_8 and UF_6
3175*	90	—	UF_6
3192	50	—	
2738	—	1,000	1989 on
2936	—	400 per year	1988-95
2962	—	500 per year	1988 on
2985	—	675 per year	1992 on
3137	—	4,800 per year	1993-97
3147	—	200	1988-92
3193	—	700 per year	1989,91,94,96
TOTAL:	575		
INACTIVE			
2760	750	750 per year	1988-90
2798	150	—	
2911	65	—	UF_6
TOTAL:	965		

*New or revised since last month.
[1]Measured from the date of this Report.
[2]For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 2987, 2991, 3120, 3209.

© NUEXCO 1987

LOAN SUPPLY AND DEMAND
(April 30, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
Available for Loan			
ACTIVE			
2909	1,000	—	
TOTAL:	1,000		
INACTIVE			
1938	2,000	—	UF_6
2036	500	—	
2912	1,000	—	
2920	2,000	—	
TOTAL:	5,500		
Inquiries to borrow			
ACTIVE			
3206*	500	—	
TOTAL:	500		

*New or revised since last month.
[1]Measured from the date of this Report.
Projects removed since last month: None.

©NUEXCO 1987

NUEXCO

CURRENT MARKET DATA

CONVERSION SUPPLY AND DEMAND
(April 30, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF_6) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale: ACTIVE			
2764B	500	—	
3222	80	—	
TOTAL:	580		
Available for Sale: INACTIVE			
2859	750	750	
2988	165	—	
3165	330	—	
TOTAL:	1,245		
Inquiries to Purchase: ACTIVE			
3120	1,000	700	1988-89
TOTAL:	1,000		
Inquiries to Purchase: INACTIVE			
2833	400	—	
2997	650	—	
TOTAL:	1,050		

*New or revised since last month.
[1]Measured from the date of this Report.
Projects removed since last month: None.

©NUEXCO 1987

CURRENT MARKET DATA

SWU SUPPLY AND DEMAND
(April 30, 1987)

Nuexco Project Number	Delivery Period[1] (Thousands of SWUs) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale:			
ACTIVE			
2571	55	—	1987
2969	200	—	1987
3173*	45	—	1987
TOTAL:	300		
INACTIVE			
3213*	150	—	1987
3322*	150	—	1987
TOTAL:	300		
Inquiries to Purchase:			
ACTIVE			
2999	150	—	1987
3159	30	—	1987
TOTAL:	180		

*New or revised since last month

[1]Measured from the date of this Report

[2]For delivery within one year. This category excludes SWUs deliverable within one year under other than spot or near-term contracts

Projects removed since last month: 3156, 3162

© NUEXCO 1987

NUEXCO

ANALYSIS AND COMMENTARY

FIVE-YEAR WORLD PRODUCTION FORECAST

Introduction

The possibility of protectionist measures designed to aid the US uranium industry has altered Nuexco's projections of future uranium production worldwide. In this revised forecast, Nuexco discusses projections for three possible future scenarios:

1. Free Market — No significant governmental restrictions limiting the international trade of uranium;
2. 50-Percent US-Origin Requirement — US utilities are required to utilize US-origin uranium for 50 percent of their consumption;
3. 75-Percent US-Origin Requirement — US utilities are required to utilize US-origin uranium for 75 percent of their consumption.

The existing sanctions on the use of South African and Namibian uranium in the USA may have an additional effect on these supply scenarios.

For the free-market case, world uranium production is expected to increase slightly from the 1986 level of 96 million pounds to about 98 million pounds in 1990 (Table 1). Figure 1 shows the annual production forecast through 1990, by geographic producing region. This free-market case indicates a relatively stable uranium industry through 1990; however, a US market restriction, whether enforced by means of an enrichment limitation or an import restriction, could cause radical changes in market share held by several producing nations. Canada and Australia, in particular, would likely lose some market share to US producers.

Table 1

WORLD URANIUM PRODUCTION FORECAST
(Millions of Pounds of U_3O_8)

Free Market Case

	1986	1987	1988	1989	1990
Australia	11	11	9	10	13
Canada	30	31	32	32	32
Central Africa[1]	10	10	10	10	10
France	8	8	8	8	8
Southern Africa[2]	21	20	19	18	18
USA	14	11	11	13	14
Other Countries[3]	2	2	2	3	3
Total	96	93	91	94	98

[1]Includes Niger and Gabon.
[2]Includes South Africa and Namibia.
[3]Includes Argentina, Belgium, Brazil, China, India, Pakistan, Portugal, Spain, and Yugoslavia.

Overview

Nuexco's forecast of world uranium consumption indicates a growth rate of only 1.8 percent per year from 1986 through 1990. As in the past, demand will be fulfilled by a combination of inventory drawdown, inventory redistribution and production. Nuexco's projection of world production is based on short-term, medium-term, and long-term economic and political considerations which affect both individual producers and the uranium production industry as a whole. In the short term, production will be primarily influenced by existing contracts as well as producers' perceptions of future market opportunities.

Uranium suppliers will continue to sell excess inventories in the spot market throughout the forecast period. This situation has prompted several other current or potential producers to cover at least some portion of their future delivery commitments with spot purchases from such selling producers. Uranium users will draw down portions of their excess uranium inventories to meet their unfilled uranium requirements. As inventory selling by utilities has essentially run its course, users will turn to traditional sources of supply, thereby stimulating additional production.

In the longer term, supply/demand and price/cost market forces will tend towards equilibrium. This equilibrium process, however, will likely continue to be affected by political factors such as selective embargoes or sanctions, government-imposed minimum prices, and production controls. Depending on their nature, these factors can result in considerable short-term distortions of the marketplace.

Analytical Method

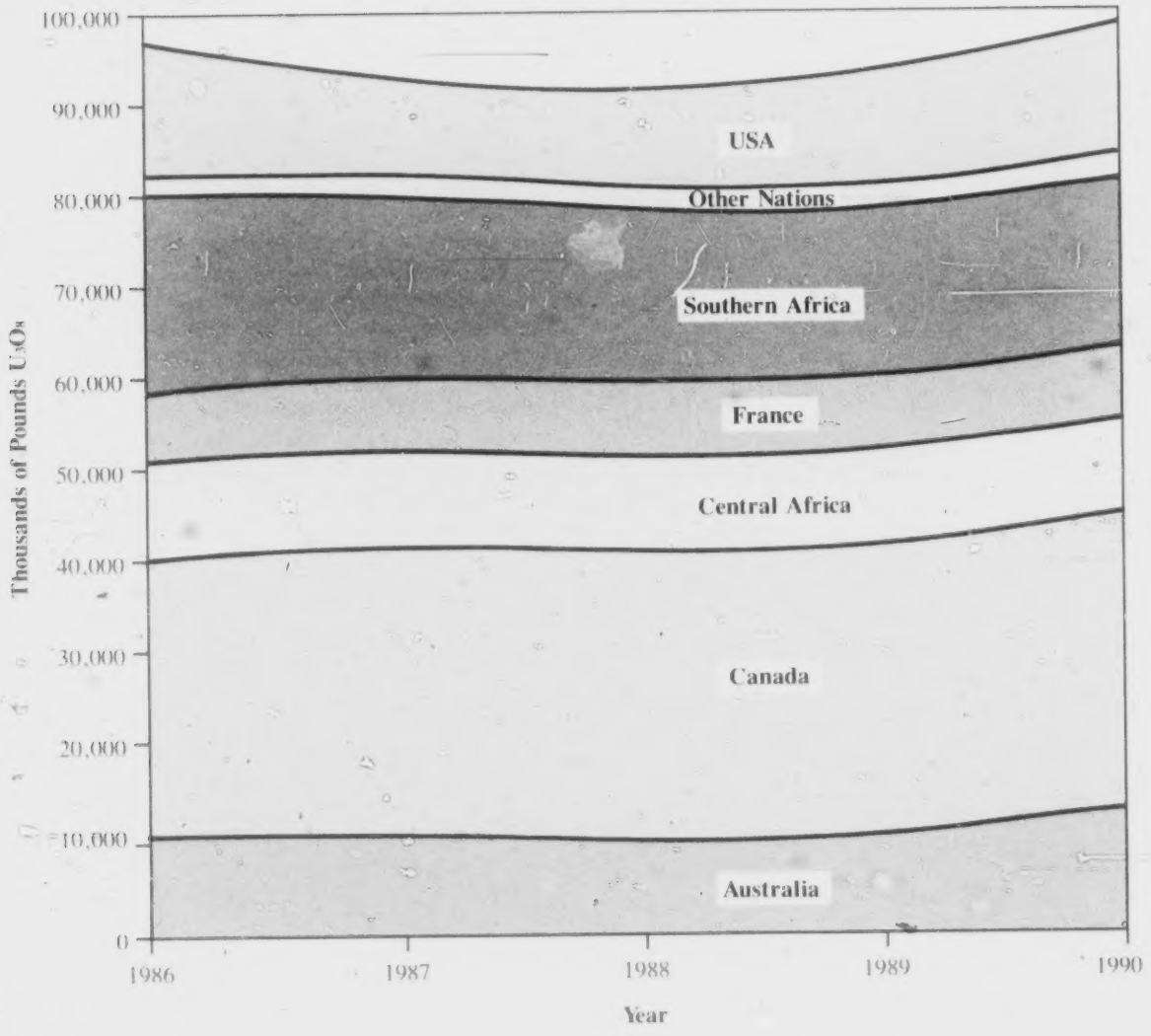
Nuexco's projection of world uranium production considers current production, announced plans for future changes in production, estimates by Nuexco of consumption on a worldwide basis, and other changes that Nuexco believes will affect producers. In the free-market case, Nuexco assumes that any political factors (embargoes, production restrictions, trade sanctions, minimum prices, and other government-induced controls) will have only minor impacts and that, in essence, a worldwide "free market" exists for the sale and use of uranium. For a given production center, the rate of production will be affected by four principal variables.

1. Production currently under contract;
2. Maximum production capability of the producing center;
3. Production costs anticipated for the center, especially relative to other production centers, and;
4. Political or institutional influences.

© NUEXCO 1987

Figure 1

FORECAST OF WORLD URANIUM PRODUCTION
FREE MARKET CASE



© NUEXCO 1987

The competition for new contracts and for spot-market sales for deliveries within the forecast period inherently favors the lower-cost producers with uncommitted production capacity. Nuexco's projection of world production considers both those producers that intend to add to or continue at relatively high production capacity and other producers that must cut back, discontinue, or postpone entering production.

Nuexco has analyzed variable and full costs of production for all world production centers, to determine which have the cost structure to remain or enter into the future market, giving due regard to the other factors which influence their decisions. Production costs can be affected to a significant degree by licensing and regulatory requirements, as well as by ore grade, royalties and taxes.

The imposition of new or more stringent uranium mining and milling regulations in Australia, Canada, and the USA has increased production costs and delayed many new projects, during periods favorable to marketing opportunities. These regulations range from worker safety to environmental impact, and affect mining, milling, tailings storage and disposal, transportation, and reclamation. New projects in the USA, Canada, and Australia have been subjected to the highest cost increases. Royalties and taxes also vary widely in those countries, with considerable variation occurring among provinces within Canada.

Nuexco also appraised a number of important political factors which could influence production within the forecast period:

1. Southern African (South Africa and Namibia) production is likely to be reduced as a result of the recent US law imposing an embargo on the importation of uranium from southern Africa. Additional reductions are possible if other nations or consumers decide to follow this same course of action.

2. Curtailment of Australian uranium production by action of the Labor Government is possible but not considered likely.

3. Production in the USA will be stimulated by any embargo or other type of restriction or limitation on the importation of non-US-origin material. Non-US production would be reduced by a similar amount.

4. Production in France and central Africa (Niger and Gabon) will likely remain stable regardless of the outcome of possible US market restrictions. Production in Spain could increase appreciably, depending on domestic political considerations.

Production Forecast for Three Scenarios

Nuexco has analyzed each individual production center from the standpoint of variable or full production costs, existing supply contracts, the potential to obtain new contracts, uranium reserve quantity and grade, the financial strength of the producer, and regulatory and other political influences of the host government. We then matched the unfilled requirements of the uranium users, plus their capability to absorb additional inventory, with the uncommitted production over the forecast period.

Free Market Case — Should a free-trade situation continue to prevail for the US uranium market, Nuexco forecasts the following trends:

1. Australian uranium production will increase by over 20 percent by 1990, to about 13 million pounds annually, as Australia begins its transition from an industry dominated by political considerations to one that is market-oriented. Nuexco believes that Australia is becoming less willing to constrain uranium production, and that the floor price and the government approval process will prove less difficult barriers to new projects and increased production.

2. Annual Canadian production may increase slightly through 1990, to about 32 million pounds. Undeveloped high-grade deposits in Saskatchewan will require long lead-times for commencement of operations and will not contribute to Canadian production during the five-year forecast period.

3. The largely captive domestic production in France is forecast to remain stable through 1990 at about 8 million pounds U_3O_8 annually.

4. Southern African (South Africa and Namibia) production is likely to decline during the forecast period as a result of the trade sanctions recently imposed by the USA, and by similar actions being taken elsewhere. Nuexco expects production from this geographic area to decrease about 13 percent, to 18 million pounds U_3O_8 in 1990. Should uranium embargoes against South Africa and Namibia become more widespread, an even greater reduction is possible.

5. Current US production is not highly competitive on a worldwide basis. However, the opening of several high-grade underground mines in New Mexico and Arizona, current by-product operations, and proposed solution mining projects could lead to a slight production increase reaching 14 million pounds annually by 1990. Much of this projected increase can be attributed to a desire by US utilities to buy US

© NUEXCO 1987

uranium, and to the desire of many foreign companies to participate, even at a small loss, in the US industry, in order to diversify their supply sources. Figure 2 shows Nuexco's forecast for US uranium production under the free-market scenario, and under restricted market conditions.

6. Uranium producers in central Africa (Gabon and Niger) may come under increasing pressure during the forecast period, due to the marginal economics of continued production from their low-grade deposits. This consideration is offset to some degree by a large component of captive production and by other concerns. Uranium production in these two countries is projected to remain approximately constant, totaling over 10 million pounds U_3O_8 in 1990.

7. A number of other countries, including Argentina, Brazil, Belgium, India, Pakistan, Portugal, Spain, and Yugoslavia, produce small quantities of uranium, primarily for use in their own nuclear programs. These countries are expected to maintain or increase their current production levels.

8. The People's Republic of China has recently entered the world uranium market with offers to sell U_3O_8 or UF_6. Their current production capability has been variously estimated at as much as 10 million pounds U_3O_8 per year, and there has been speculation that inventory could be as much as 80 million pounds U_3O_8. China could make available for sale during the forecast period as much as several million pounds U_3O_8 per year.

50-Percent US-Origin Requirement — Since the USA already faces the prospect of importing about half of its requirements within the forecast period, restrictions up to that percentage would not significantly affect the balance between US and non-US production.

Nuexco projects that in this case, US production would increase by about 4 million pounds to about 18 million pounds in 1990 (Figure 2), and that this increase would be fulfilled largely by a combination of reactivated conventional production from the Colorado Plateau, and by solution mining production from several new projects.

75-Percent US-Origin Requirement — Assuming that a 75-percent US-origin requirement is imposed on US utilities, there would immediately develop a surplus of production capacity for non-US uranium and a deficiency for US-origin uranium. Restrictions in excess of 50 percent of US requirements will affect a number of current and potential producers throughout the world. The greatest impact in terms of tonnage is likely to be upon Canada, which provides the largest portion of US imports and which has several high-cost, independent producers still in operation. Lesser effects would be felt elsewhere.

In the USA, a 75-percent embargo on the use of non-US-origin in US reactors would greatly stimulate domestic uranium production. Facilities currently on standby would be reactivated, solution mining projects currently under development would be completed earlier, and by-product uranium operations would experience a resurgence of production. Although some known higher-cost conventional uranium might be brought into production, the risks associated with large-scale, high-cost conventional production could be too high, and therefore many producers are likely to be more attracted to smaller, less capital-intensive projects. Nuexco forecasts that a 75-percent embargo on non-US uranium would result in an increase in US production of 74 percent, to about 25 million pounds U_3O_8 by 1990 (Figure 2).

The 50-percent US-origin requirement is projected to cause an increasing effect beginning in 1988, after a very slight increase in 1987. The 75-percent US-origin requirement produces an earlier and much larger effect.

Factors Influencing Production

Nuexco expects lower-cost production to continue displacing higher-cost production during the forecast period, even though much of the higher-cost production may currently be produced for delivery under existing contracts. Uranium produced from operating by-product recovery facilities is not at all sensitive to market price fluctuations, since the primary products determine the facilities' operating levels. However, startup of new by-product uranium recovery facilities is as sensitive to expectations of future market prices as are operations producing uranium as a primary product. High-cost, independent producers are likely to be forced from the future market should prices remain low. Under Nuexco's forecast:

1. Producers in the best position are those that can operate existing facilities or quickly startup new production facilities at a profit.

2. Producers whose existing facilities can produce uranium at costs equal to or below the market price, and thus recover some portion of their capital investment and interest charges, are likely to continue operation in the expectation of a better uranium market in the future.

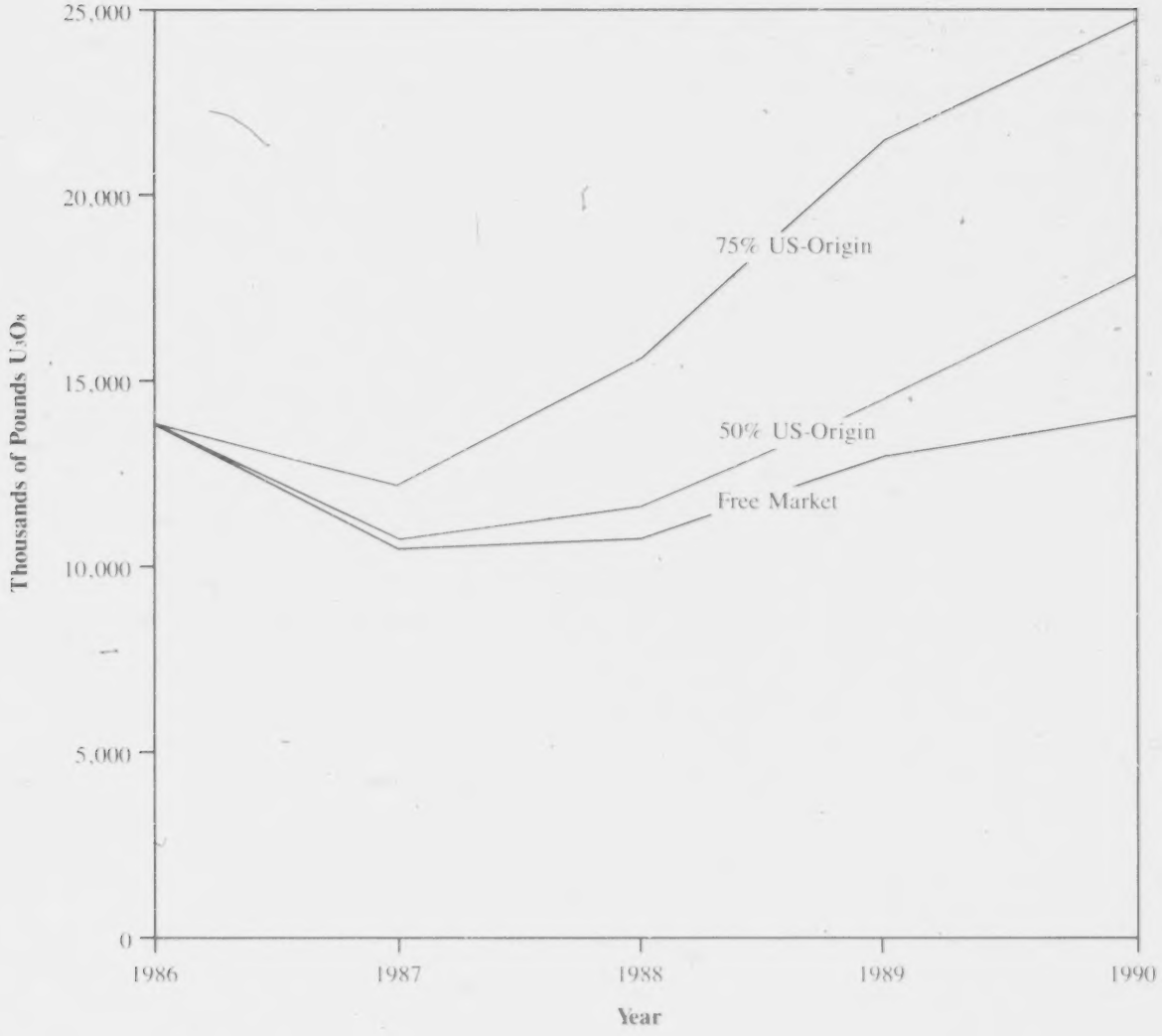
3. Certain higher-cost producers operating below rated production capacity may elect to fulfill existing contracts from their own production facilities, but may be unable to produce economically for new contracts.

4. Producers who can improve their economic position by purchasing their future contract delivery requirements from

© NUEXCO 1987

Figure 2

FORECAST OF US URANIUM PRODUCTION UNDER FREE-MARKET AND RESTRICTED-MARKET SCENARIOS



© NUEXCO 1987

inventory sellers or other producers may discontinue production or place their own facilities on standby.

5. Certain producers with extensive financial backing, whose losses are budgeted over a given time period, may elect to continue minimum production, even though it may be subeconomic to do so.

6. Some high-cost production centers which are captive to national entities or governments will, as a matter of policy, continue operation, despite poor economics.

7. Producers who recover uranium as a by-product of their major operations may have variable uranium production costs which are quite low; in those instances, they will continue by-product production as long as the combined production is profitable.

8. Producers with facilities on standby will return to the market when prices rise to a level that the producers believe will sustain operation at or near profitable levels.

Conclusion

Under the free-market scenario, annual worldwide uranium output would increase by only about two million pounds by 1990. Utilities' consumption of excess inventory material and producers' sales will provide approximately 20 percent of the required fuel during the five-year forecast period. Imposition of a 50-percent embargo on uranium imported into the USA for use in US reactors is projected to cause only a modest increase in US production. The 75-percent case, however, would immediately result in a surplus of production capacity for non-US uranium, and a deficiency in capacity for the US uranium production industry; production in the USA would increase by nearly 75 percent above the free-market scenario in 1990. Most other countries would experience a reduction in uranium output. In sum, a 75-percent US embargo would immensely stimulate US production, while creating a large shift in relative market share for virtually all of the world's other uranium producers.

©NUEXCO 1987

NUEXCO

RECENT DEVELOPMENTS

JAPAN

In April 1987, Japan's Ministry of International Trade and Industry (MITI) released an outline of power facility construction plans for FY87 and FY88. This outline summarized plans submitted by several Japanese utilities to the Electric Power Development Coordination Council (EPDCC), and showed a vigorous plan for nuclear plant construction over the next several years (Table 2). EPDCC is the government organization that gives approval for planning; such approval allows the utility to apply for site licensing and construction permits. Despite reduced sales of electric power to industrial consumers in the past year, plans for the increase in nuclear construction are based on a projection that the annual increase in peak electric power demand could be as high as 2.8 percent through the mid-1990s.

Under the proposed plan, Tokyo Electric Power Company (TEPCO) would begin construction of Kashiwazaki-Kariwa Units 6 and 7 (1,355-MWe BWRs) during FY87 (which ends in March 1988), with commercial operation scheduled for 1996 and 1998 respectively. Earlier, the EPDCC had approved licenses for Kashiwazaki-Kariwa Units 3 and 4. License applications for these units were made in April 1985, and Unit 3 is expected to begin construction in June 1987.

Tohoku Electric Power Company applied to the EPDCC for approval to begin construction on Higashi Dori Unit 1 (1,100-MWe BWR) and Namie-Odaka (825-MWe BWR) during FY1988, which would begin commercial operation in 1997 and sometime after 1998 respectively. Tohoku also revealed preliminary plans for future construction of Totsu Unit 1, which could begin construction in 1991 or 1992. EPDCC had

Table 2

PLANNED NUCLEAR POWER PLANTS IN JAPAN

Unit Approved[1] Planned Units	Utility	Capacity (MWe Gross)	Type	COD[2]
Ohi 3	Kansai EPC[3]	1,180	PWR	Aug 1991
Ohi 4	Kansai EPC	1,180	PWR	Jun 1992
Noto 1	Hokuriku EPC	540	BWR	Mar 1993
Kashiwazaki-Kariwa 3	Tokyo EPC	1,100	BWR	Jul 1993
Kashiwazaki-Kariwa 4	Tokyo EPC	1,100	BWR	Jul 1994
Hamaoka 4	Chubu EPC	1,137	BWR	Jul 1994
Onagawa 2	Tohoku EPC	825	BWR	Jul 1995
Maki 1	Tohoku EPC	825	BWR	Sep 1996
Total gross capacity		7,887		
Plans Submitted for Approval				
Kashiwazaki-Kariwa 6	TEPCO EPC	1,355	BWR	1996
Kashiwazaki-Kariwa 7	TEPCO EPC	1,355	BWR	1998
Higashi-Dori 1	Tohoku EPC	1,100	BWR	1997
Namie-Odaka	Tohoku EPC	825	BWR	1998
Ashihama 1	Chubu EPC	1,100	PWR	1996
Ashihama 2	Chubu EPC	1,100	PWR	1997
Toyokita 1	Chugoku EPC	1,100	BWR	1997
Toyokita 2	Chugoku EPC	1,100	BWR	1999
Ohma	EPDC[4]	606	ATR	1998
Total gross capacity		9,641		

[1]Approved for planning but without authorization to start construction at this time. Following completion of public hearings, plans are submitted for the approval of the Electric Power Development Coordination Council (EPDCC).
[2]Expected Commercial Operation Date.
[3]Electric Power Company.
[4]Electric Power Development Company.

© NUEXCO 1987

earlier approved plans for construction of Tohoku's Onagawa Unit 2 (825-MWe BWR), beginning in February 1989, scheduling for commercial operation in 1995.

Chubu Electric Power Company has proposed to the EPDCC to start construction on Ashihama Units 1 and 2 (1,100 MWe PWRs) in March 1989. These units would be scheduled for commercial service in 1996 and 1997 respectively. Chugoku Electric Power Company also proposed construction of two plants, Toyokita Units 1 and 2 (1,100-MWe BWRs), to begin in March 1989, with completion in late 1997 and late 1999. The Electric Power Development Company (EPDC) proposed a December 1988 start for construction of its Ohma unit, a demonstration 606-MWe Advanced Thermal Reactor (ATR), with completion scheduled for 1998.

Assuming the units are started as proposed, 9,640 MWe of nuclear power capacity will have been placed under construction within the next two years, by the end of Japan's 1988 fiscal year. Such a construction program would increase Japan's share of nuclear electricity generation from 27 percent in 1986 to about 37 percent by 1996.

* * * *

Annual negotiations held in April between several Japanese utilities, including Tokyo Electric Power Co. (TEPCO), and Namibia's Rossing Uranium Limited have resulted in a contract price of slightly less than US $31.00 per pound U_3O_8. This represents a price reduction of about $1.00 per pound U_3O_8 from the price paid for the previous year's deliveries. Rio Tinto Zinc (RTZ) is the project's operator and largest shareholder. The low uranium spot prices prevalent during 1986 and early 1987, as well as generally low petroleum prices, have influenced the negotiations, enabling the Japanese utilities to further decrease the price paid under their long-term contracts.

SOUTH AFRICA

First-quarter uranium output from Chamber of Mines producers totaled 2,714,000 pounds U_3O_8, a decline of 2.4 percent from the fourth-quarter of 1986 (Table 3). Decreased output from Buffelsfontein (a 10-percent drop), Harmony (a 12-percent drop) and Randfontein (a 12-percent drop) chiefly accounted for the overall decline. Driefontein Consolidated, Hartebeestfontein and Western Areas also posted smaller declines. Output from the other producers remained approximately constant or increased slightly. Nuexco expects South Africa to produce about 11.4 million pounds U_3O_8 this year.

Table 3

REPUBLIC OF SOUTH AFRICA
RECENT URANIUM PRODUCTION[1]
(Thousands of Pounds U_3O_8)

Operation	Fourth Quarter 1986	Total 1986	First Quarter 1987	Percent Change[2]
Buffelsfontein	302	1,316	271	−10.3
Driefontein Consolidated	43	180	41	− 4.7
ERGO[3]	86	343	88	+ 2.3
Harmony	116	728	102	−12.1
Hartebeestfontein	257	1,025	242	− 5.8
JMS[4]	266	1,168	275	+ 3.4
Randfontein	356	1,324	314	−11.8
Stilfontein (Chemwes)	226	638	228	+ 0.9
Vaal Reefs	997	4,255	1,025	+ 2.8
Western Areas	133	585	127	− 4.5
TOTAL[5]	2,782	11,562	2,714	− 2.4

[1]Excludes Palabora Mining Company, which is not a member of the Chamber of Mines.
[2]Change in percent from the fourth quarter of 1986.
[3]ERGO = East Rand Gold and Uranium Company Ltd.
[4]JMS = Free State Joint Metallurgical Scheme (Freegold).
[5]Columns may not add due to rounding.

© NUEXCO 1987

NUEXCO

BY-PRODUCT AND CO-PRODUCT URANIUM RESOURCES AND PRODUCTION

Introduction

Uranium occurs as a minor constituent in a number of minerals or mineral groups, only a few of which are important as uranium resources. Uranium produced under circumstances secondary to the production of another mineral is considered a *by-product*. Where uranium and another mineral are of relatively equal economic importance, they are termed *co-products*. Although the potential quantity of by-product uranium available worldwide is quite large, the rate and timing of production of the primary mineral controls the production rate of uranium. In most cases, the primary mineral's economic viability must support the project, while the economics of uranium production merely may offer added incentive to initiate the project.

South Africa provides perhaps the best example of uranium by-product production and economics. About 98 percent of known uranium resources in South Africa occur in association with gold in quartz-pebble conglomerates of the Witwatersrand district. During the first 65 years of mining activity uranium contained in the mined ores was sent directly to the tailings dams. By the early 1950s, recovery as a by-product of gold production had established an important uranium source. More recently, uranium recovered from the reprocessing of older tailings has added to overall production.

The numerous marine phosphate deposits scattered throughout the world, and the massive sulfide deposit at Olympic Dam, in Australia, provide other large sources of by-product and co-product uranium. Several producers in the USA and other countries extract uranium from phosphates, and a number of other countries have established pilot recovery projects in recent years. Commercial operations are scheduled to begin by late 1988 at the Olympic Dam deposit in Australia; uranium will be produced as a co-product with copper and gold. On a smaller scale, some producers are recovering uranium from mine waters in certain underground mines in the Ambrosia Lake district of New Mexico. Insofar as mine water recovery of uranium uses only the natural formation water, with no chemicals added to enhance leaching, the uranium is considered a by-product of conventional mining and recovery practices.

There also are several less important sources of by-product uranium which have been exploited in the past and which may or may not be sources of future production. These include beryllium ores in Utah, copper ores in Arizona and Utah, as well as in India, the USSR and South Africa, lignites in North and South Dakota, and rare earth recovery projects. Finally, considerable research has been undertaken to recover by-product uranium from marine black shales and from seawater. However, recovery costs have thus far greatly exceeded what would be necessary to establish economic viability. Limited research continues in both areas, but mainly in processes aimed at extracting uranium from seawater.

Overall, by-product uranium is a significant part of the worldwide uranium resource base. In the USA, for example, since 1982, conventional production has declined by almost 60 percent, output from solution mining has dropped by half, while by-product uranium production has increased slightly, from 3.2 million pounds U_3O_8 to 3.6 million pounds. Thus, by-product output has increased its share of US production from 12 percent in 1982 to 26 percent in 1986, after peaking at 32 percent in 1985.

Quartz-Pebble Conglomerates

Uranium found in conjunction with gold in the Witwatersrand complex of South Africa constitutes one of the world's largest commercially viable by-product uranium resources. South Africa's Reasonably Assured Resources (RAR) associated with gold mineralization and based on an estimated production cost of less than US$30 per pound U_3O_8 are estimated at over 560 million pounds U_3O_8 (256,000 tonnes); an additional 57 million pounds (26,000 tonnes) are contained in mill tailings, for a total of over 620 million pounds (282,000 tonnes). Estimated Additional Resources (EAR) in the same cost-recovery category would increase the total by another 216 million pounds U_3O_8 (98,000 tonnes).*

Uranium production began in 1952 at some operating gold mines in the Witwatersrand district. Annual output gradually increased, reaching a high of 16.1 million pounds U_3O_8 (7,300 tonnes) in 1980 when 21 mines supplied gold-uranium ore to 19 recovery facilities. Production declined to about 5,550 tonnes in 1986, the lowest level since 1978. Total production from uranium-bearing gold ores for the 1952-1986 period was approximately 300 million pounds (137,000 tonnes) U_3O_8.

The gold-uranium mineralization is confined to a number of reefs (conglomeritic beds) over a vertical thickness of about 4,000 meters and a fairly consistent lateral extent of 100-plus kilometers. Reserve estimates indicate that approximately 100 million tonnes of gold ore contain concentrations of uranium ranging from 0.20 to 2.00 pounds U_3O_8 per

* Source: *Uranium: Resources, Production and Demand*, OECD Nuclear Energy Agency/IAEA, 1986.

© NUEXCO 1987

tonne, almost all of which is found in the northern and western parts of the basin. Uraninite is the only uranium mineral identified in the reefs.

The ore minerals occur in an irregular sedimentary sequence of conglomerates and siltstones deposited in coalescing fluvial fans along the fault margins of the basin. The minerals occur as fine detrital particles in the conglomerates, with pyrite as an important accessory mineral (all minerals are syngenetic in origin). Ore concentration is a function of specific gravity plus depositional environment; ordinarily, higher gold content means lower uranium content, and vice versa.

The exploitation of a gold-uranium deposit is determined almost exclusively by the economics of gold production and only minimally by the economics of uranium. Historically, as gold prices have risen, producers have lowered their cutoff grades for mined ore. Mining a lower cutoff grade decreases the average grade of gold in the ore that is processed, but total recovered gold increases because of an increase in throughput at the recovery facility. Uranium occurs in association with the gold, so uranium output can, but does not necessarily, respond in the same way to an increase in *gold* prices.

Operators of uranium processing facilities may or may not decide to produce more uranium as a result of increased gold throughput at the gold recovery plant. If uranium prices are not high enough, they may choose to stockpile the uranium as tailings, to be processed at a later date. The price of uranium usually has little influence on this type of mining, although when uranium prices were above US $35 per pound U_3O_8, a few mines were developed mainly for uranium production, with gold being a by-product or co-product at those operations.

The basic mineral recovery process begins with coarse-grinding and gravity concentration of minerals. The heavy concentrate is then finely ground and subjected to an acid-leach/cyanidation for uranium and gold separation. The pregnant solution from both streams is clarified and sent to the ion exchange circuit. The resulting concentrate then travels to the mixer-settler (solvent extraction) circuit. Precipitation takes place when ammonium sulfate is added to the uranium-rich solution to produce an ammonium diuranate slurry (ADU) which is then calcined and packaged as U_3O_8. The tails stream is subjected to further leaching and cyanidation for final uranium and gold extraction, and to floation for pyrite extraction.

Uranium, gold and pyrite contained in the tailings at each gold recovery plant throughout the Witwatersrand Basin represent important secondary mineral resources. Although gold is the primary mineral recovered, uranium (averaging about 0.10 percent U_3O_8 per tonne) and pyrite both are potentially significant to project economics. Secondary recovery of pyrite is particularly important because originally most of the gold and part of the uranium is contained in pyrite particles. Sulfuric acid produced from the pyrite also may later be used in the uranium recovery process at conventional recovery plants.

Tailings recovery usually involves hydraulic sluicing. The sluiced material is introduced into the grinding circuit for fine-grinding and from that point the recovery process closely follows that of newly mined ore. Uranium was first produced from processed tailings in early 1978 by the East Rand Gold & Uranium Co. Ltd. (ERGO). Production from tailings at ERGO has since averaged about 400,000 pounds U_3O_8 annually.

Uranium from Phosphates

Estimates of worldwide marine phosphate resources show approximately 129,000 million tonnes, 80 percent of which are found in the USA, Morocco and the USSR. All deposits contain uranium as a trace element in amounts varying from approximately 50 to 200 parts per million (ppm). In addition, phosphate rock often contains up to three percent fluorine and traces of vanadium, thorium and rare earths, all of which are nonrecoverable using current technology.

The original depositional sequence of a primary phosphate deposit typically results in very low phosphate (P_2O_5) and uranium contents. High-grade (commercial grade) deposits are formed by weathering and reworking of the primary deposit in a marine environment. Certain environments may increase the phosphate content of the rock to more than 30 percent, but as a rule, the average is somewhat less. The Bone Valley Formation in Florida contains 10 to 15 percent phosphate; deposits in Idaho, Utah and Wyoming may contain from 18 to 24 percent. Mined rock undergoes a treatment process to increase phosphate content to over 30 percent (the minimum requirement for commercial fertilizer).

World production of marine phosphorite totaled 120 million tonnes P_2O_5 in 1986. In the USA, an estimated 31 million tonnes was produced in the Florida district, and production in the western USA was approximately another ten million tonnes. All phosphorite rock potentially can yield by-product uranium (for example, about 0.8 pounds U_3O_8 per tonne of Florida phosphoric acid processed), and US producers recovered about 3.6 million pounds U_3O_8 from Florida rock in 1986.

The most important consideration for US producers of U_3O_8 as a by-product of phosphoric acid is the uranium content of the source rock. Each phosphate uranium producer

© NUEXCO 1987

in the USA, past and present, has had mines in the central and southern Florida district, the area having the greatest economic potential both for phosphoric acid and uranium production. The deposits that occur in the Bone Valley Formation have the highest grade phosphate and uranium content in the region, averaging approximately 0.015 percent U_3O_8 (equivalent to 0.3 pounds U_3O_8 per short ton of phosphate rock), compared to 0.008 percent for the remainder of the region.

Currently, uranium cannot be extracted directly from phosphate rock; uranium recovery takes place during phosphoric acid production. The production of uranium from phosphates requires "wet process" technology, which uses sulfuric acid to dissolve the phosphate rock (acidulation). The process creates phosphoric acid, with gypsum precipitated as a waste-product, which is filtered out as tailings. Depending on redox potential, from 85 to 95 percent of the natural uranium is codissolved with the phosphorite and stays with the phosphoric acid. Recovery of uranium from the phosphoric acid stream usually exceeds 90 percent. Uranium cannot be recovered from phosphoric acid made from elemental phosphorus, the process used on phosphate rock at production centers in the western USA.

The technology for extracting uranium from phosphoric acid originally was developed by the US Atomic Energy Commission (AEC) in 1947. Four US phosphoric acid producers participated in the AEC's research and development project, which focused on the Pyro solvent extraction process, called the OPPA process (after the *octylpyro-phosphoric acid* extractant). The process consisted of four basic steps following acidulation:

1. Reduction of uranium contained in phosphoric acid by the addition of iron;

2. Solvent extraction utilizing octylpyro-phosphoric acid diluted with kerosene;

3. Clarification of the pregnant solution, and;

4. Stripping, precipitation, purification and drying of the uranium concentrate.

The project produced slightly more than one million pounds U_3O_8 from 1954 to 1962, when it was terminated because production costs were no longer competitive with new conventional uranium mining projects in New Mexico and Wyoming.

The Oak Ridge National Laboratory (ORNL) also operated a pilot recovery program throughout the 1960s and into the mid-1970s, developing two additional recovery processes based on improved solvents and new technology. The DEPA-TOPO process (after *di-2-ethyl-hexyl phosphoric acid* [D-EHPA] and *tri-octyl-phosphine oxide* [TOPO] extractants) was developed in the late 1960s, and the OPAP process by the early-1970s. The DEPA-TOPO process has proven to be the most commercially efficient recovery method. This two-stage process uses a solvent mixture to extract, concentrate and purify uranium. The OPAP process uses the solvent octylphenyl acid phosphate to concentrate the uranium, which is extracted and purified with DEPA-TOPO solvent during a second stage.

Treatment of the acid is one of the most important steps in using the basic DEPA-TOPO recovery process. Florida phosphate rock contains about one percent organic material, much of which is soluble and cannot be removed by filtration. Its presence creates "black" acid, an undesirable product that tends to coagulate on contact with DEPA-TOPO extractant, forming a "crud" which interferes with uranium extraction. Organic-free acid is referred to as "green" acid from which uranium is readily recovered.

Proprietary technology has been developed by several organizations to remove organics from the acid stream. Oak Ridge National Laboratory developed the use of activated carbon to remove the organic material, reportedly improving solvent extraction, reducing scaling in pipes and tanks, and allowing the use of chemical rather than thermal regeneration. Current operators may use various methods, including activated carbon, to remove the organic humates, but the desired end result in every case is clean, "green" acid.

Primary uranium extraction begins with oxidation of the uranium, followed by the addition of DEPA-TOPO solvent and an organic solution which causes the uranium to transfer to the solvent. The uranium-bearing solution is separated from the phosphoric acid, and the uranium-free acid (raffinite) returns to the acid plant for final processing into fertilizer and related products. By bringing the solvent into contact with a small amount of phosphoric acid treated with metallic iron, the uranium is stripped from the loaded solvent and reduced to the tetravalent state.

Secondary extraction includes another oxidation stage to recreate hexavalent uranium. The oxidized uranium in-solution, which contains a high concentration of uranium from the primary circuit, is reloaded onto DEPA-TOPO solvent. The loaded solvent is cleaned with a water rinse and then stripped by adding ammonium carbonate to form a precipitate of ammonium uranyl tricarbonate (AUT). The AUT is then filtered, leaving uranium concentrate (yellowcake) ready for drying and packaging. Uranium recovery normally varies from 0.5 to 1.3 pounds U_3O_8 per short ton of phosphoric acid processed, depending on the phosphorite rock's uranium content and the efficiency of the recovery process.

Many steps in the DEPA-TOPO recovery process have been modified and are now considered proprietary by the different participating companies. The above procedures are

©NUEXCO 1987

basic to recovery technology and should not be considered as a complete or final process outline. Worldwide, there were eight DEPA-TOPO plants operating in 1981; six in the USA, one in Belgium and one in Taiwan. By the end of 1986, US operating production facilities had declined to four, with one new producer in Canada. (Two companies had operated OPAP plants, both of which were closed by 1981.) Table 4 lists the companies, rated annual capacity and location of plants extracting uranium from phosphates.

Multi-Mineral Ores

At present, by-product recovery of uranium from multi-mineral ores is limited to operations in South Africa, the USA and the USSR. In South Africa, multi-mineral by-product uranium is recovered from copper sulfide reserves at the Palabora mine. In the USA the many waste dumps associated with porphyry copper mines also could provide a resource base. Historically, the USSR has produced a great deal of uranium from low-grade uranium ores associated with other minerals. Several other countries including India and Argentina recover uranium during processing of copper ores; although total recovery has been small, the potential resource base is important to those countries.

Australia has the greatest potential for recovery of co-product uranium from multi-mineral ores. Estimates made of the Olympic Dam copper/uranium/gold deposit indicate over 2 billion tonnes of ore, with a uranium content of 0.06 percent U_3O_8, or approximately 2.6 billon pounds U_3O_8. Commercial development of the deposit has begun and uranium recovery is integral to the project's economics.

Australia — The copper/uranium/gold deposit located in South Australia is perhaps the largest sulfide mineral accumulation ever discovered, covering an area of 20 square kilometers. Estimated reserves total over two billion tonnes

Table 4

PLANTS FOR BY-PRODUCT RECOVERY OF URANIUM FROM PHOSPHATES

Company	Location	Process Type	Annual Capacity (thousand pounds U_3O_8)	Start/Close	Production (thousand pounds U_3O_8) 1984	1985	1986
Intl. Min. & Chem. (IMC)	New Wales, FL	DEPA-TOPO	1,400	1980/OP[2]	900	1,150	1,100
IMC/C.F. Industries	Plant City, FL	DEPA-TOPO	700	1980/OP	600	750	700
Freeport Uranium Co.	Uncle Sam, LA	DEPA-TOPO	800	1978/OP	797	670	700
Freeport Uranium Co.	Donaldsonville, LA	DEPA-TOPO	450	1981/OP	432	426	400
Earth Sciences/UG[2]	Calgary, Alberta	DEPA-TOPO	120	1983/OP[4]	104	118	90
Chemie Rupel	Engis, Belgium	DEPA-TOPO	150	1980/OP[4]	120	120	120
China Phosphate	Taiwan	DEPA-TOPO	50	1981/OP[4]	—	—	—
IMC/C.F. Industries[6]	Bartow, FL	DEPA-TOPO	700	1980/85	0	132	0
UG USA	Pierce, FL	DEPA-TOPO	450	1978/81[5]	—	—	—
Uranium Recovery Corp.	Bartow, FL	OPAP	330	1976/80	—	—	—
UNC	Mulberry, FL	OPPA	100	1955/61	—	—	—
U.S. Phosphoric	Tampa, FL	OPPA	200	1955/61[7]	—	—	—
Gardinier	Tampa, FL	OPPA	450	1979/82	—	—	—

[1]OP = Plant operating as of Jan. 1, 1987.
[2]Earth Sciences Inc./UG-USA/Western Coop. Fertilizers Ltd. joint venture, processing Florida phosphate rock.
[3]Production from imported phosphate rock.
[4]Originally Wyoming Mineral Corp.-Farmland Industries. Sold to Uranium Extraction Florida, Inc. (UEF) in 1985. Currently owned by UG (Urangesellschaft) USA. Plant undergoing renovation with start-up (DEPA-TOPO process) in near future.
[5]Uranium recovery facility on stand-by.
[6]Sold to Gardinier, plant renovated and re-started in 1979.

© NUEXCO 1987

of ore, averaging 1.6 percent copper, 0.06 percent uranium, and 0.6 grams/tonne of gold. The deposit is owned by the joint venture of Roxby Mining Corporation Pty. Ltd. (a wholly-owned subsidiary of Western Mining Corp.) with 51 percent, and the BP Group (BP Australia Ltd., and BP Petroleum Development Ltd., 36.5 and 12.5 percent respectively) with 49 percent.

Delineation drilling has revealed an internal high-grade ore block containing approximately 450 million tonnes of ore with average grades of 2.5 percent copper, 0.08 percent uranium, 0.6 grams gold and 6.0 grams silver per tonne. The uranium contained in that high-grade ore block is estimated at over 800 million pounds U_3O_8 (360,000 tonnes). During 1980/81 the operators sank an exploration shaft to a depth of 500 meters in the high-grade ore block in order to carry out a detailed underground evaluation program.

The partners made a decision in December 1985 to proceed with commercial development of the high-grade block, based on recovery of the three principal minerals. Construction began in March 1986 in preparation for initial production by mid-1988. The first development phase will allow the operators to produce approximately 30,000 tonnes of refined copper, 5.2 million pounds U_3O_8, and 90,000 ounces of gold. To accomplish this production goal, the mining rate will be increased to about one million tonnes of copper ore, 0.5 million tonnes of gold ore, and 0.5 million tonnes waste per year. Eventually, annual copper production could total about 150,000 tonnes, and U_3O_8 will total about 8.8 million pounds.

South Africa — The presence of uranium in association with copper sulfide minerals in the Palabora deposit of South Africa was first noted in 1952. Uranium was first recovered from the ore in 1971, and by the end of 1986, approximately 7.3 million pounds of U_3O_8 (3,300 tonnes) had been produced as a by-product. Output at Palabora averaged 480,000 pounds U_3O_8 during the years 1981 to 1985, with a peak of nearly 570,000 pounds (260 tonnes) in 1982. Recoverable resources contained in the remaining mineable copper ore are estimated at approximately 2.4 million pounds U_3O_8 (1,100 tonnes) at an average grade of 0.0035 percent uranium.

USA — In 1965, the US Bureau of Mines noted the presence of uranium in acid solutions used to leach the oxidized ores and waste dumps at copper deposits throughout the western USA. By 1967, Kennecott Mining Company and the Bureau of Mines had constructed an 800 gpm pilot project to perfect an ion exchange uranium recovery process at the Bingham Canyon mine in Utah.

Kennecott contracted with Wyoming Mineral Corp., a subsidiary of Westinghouse Electric Corp., to establish a commercially viable recovery process in 1974. Wyoming Mineral designed and constructed a 6,700 gpm plant to treat leach solutions migrating through waste dumps and feeding the copper cementation plant. The uranium recovery plant, which collected the solution downstream of the copper plant, began operating in 1977 at a rated annual capacity of 140,000 pounds U_3O_8. The plant operated at capacity in 1982, but by 1985 production had declined to only about 60,000 pounds. Wyoming Mineral placed the operation on standby in 1985, and later sold it to Energy Fuels Nuclear in 1986. Energy Fuels reopened the plant in February 1987 and will be producing at a rate of approximately 10,500 pounds U_3O_8 per month.

Anamax, a 50/50 joint venture of Amax, Inc. and the Anaconda Company, also produced by-product uranium at the Twin Buttes porphyry copper open-pit mine at Sahuarita, Arizona. The deposit's upper mineralization consisted of a copper oxide halo containing uranium measured at about 10 to 15 ppm, just enough to contaminate the copper mined from the oxide zone. To recover the uranium, the ore was treated by acid leaching, with the disolved uranium and copper being separated in the copper solvent extraction circuit. The uranium recovery plant's rated capacity was about 120,000 pounds U_3O_8 annually. Uranium production began in 1980, growing to over 200,000 pounds in 1981 and 1982. Output had declined to about 100,000 pounds by 1985 as oxide ore reserves were depleted. The uranium plant was shut down in November 1985.

USSR — By-product uranium has been produced from mines in almost every metal mining district of the country, stretching from the Siberian and Aldan shield regions in the northeast to the southern limits of the Chatkal/Ferghana district in Uzbekistan. In each district, uranium may occur in association with one or more minerals including copper, vanadium, molybdenum and galena. Lignite also provides some uranium by-product recovery in three different areas in the vicinity of the Osh lignite belt. In addition, uranium is recovered from iron ore in the Terny/Zholtye Vody mines located in the heart of the Krivoi Rog iron district in Dnepropetrovsk Province. Although information about the quantity of by-product uranium production in the USSR is not publicly available, such resources will continue to be an important source of uranium in the USSR.

Uranium from Mine Water

A few underground mines in the Ambrosia Lake district of the Grants mineral belt in New Mexico currently recover uranium by processing groundwater pumped from the mines.

© NUEXCO 1987

Quivira Mining Company (a subsidiary of Kerr-McGee Corp.) produced 146,000 pounds U_3O_8 from mine water at its Ambrosia Lake operations in 1986. Homestake Mining Company produces about 250,000 pounds U_3O_8 annually from mine water recovery.

Water containing from 4 to 7 ppm uranium flows naturally into the mine workings, where it is pumped to the surface and passed through an ion exchange circuit to remove the uranium. The water is then returned to the mine site and reinjected through drill holes into mined-out stopes, where it makes contact with broken ore, achieving concentrations of up to 15-30 ppm uranium. Under carefully controlled conditions, the uranium content may increase to 40-60 ppm, but this usually does not occur on a sustained basis.

The cycle of pumping and stripping continues repeatedly as the pregnant solution from the ion exchange circuit is further processed by conventional methods to produce uranium oxide. Several million pounds of uranium have been produced by following this method over the past few years. Uranium also is recovered from mine water in underground mines in France and from the Ranger open-pit mine in Australia. The water is not recycled after uranium extraction.

Although the potential for such production exists in all underground uranium mines where formation water commonly occurs, it represents a limited resource base whose size is difficult to estimate. However, it is possible that 10 to 15 percent of reserves associated with a wet underground uranium mining operation could eventually be recovered by processing mine waters.

Minor and Potential Resources

Small-scale by-product uranium production has been achieved from several different sources in the past, such as lignites, beryllium and rare earths. Other potential resources include black marine shales, and seawater. As with most other by-product sources, the nature of the uranium occurrence and economics of the by-product recovery processes, as well as the market for uranium, have had the greatest influence on production.

Lignite — The uranium content of most lignites and coals is extremely low, and potential recovery from ash is uneconomical. A study by the US Geological Survey failed to identify any lignite or coal in the USA that could be considered an important source of uranium. However, during the 1950s and 1960s a few isolated lignite sources were mined for unusually high uranium content (from 0.05 percent to 1.00 percent U_3O_8) in North and South Dakota. The uranium (and molybdenum) was concentrated in the lower portion of the lignite seam, indicating probable redistribution of uranium through weathering and alteration.

To recover the uranium, the operators mined and hauled the mineralized portion of the lignite seam to a plant for burning and ash collection. Uranium retained in the ash could be concentrated three to six times, after which the ash was transported to a conventional mill for mixing and processing with regular mill feed. Lignites in North and South Dakota produced totals of 595,000 and 744,000 pounds respectively. It is extremely unlikely that future mining of these deposits for uranium will occur due to economic and environmental considerations. Other lignite occurrences are not known to be mined sources of by-product uranium, except those already mentioned in the USSR. Uraniferous lignites occur in South Africa but have not been mined to date.

Beryllium — Several large deposits of uraniferous beryllium were discovered in the Topaz-Spor Mountain area of western Utah in 1959. The mineralization is disseminated in water-laid tuffs in which the average uranium content is approximately 0.015 percent U_3O_8. Brush Wellman Inc., owner of the deposits, began mine development and mill construction in 1968; beryllium production started in 1969 at a rate of 350 tons of ore per day. The mine and mill presently is the only beryllium extraction project in the western world.

The principal ore mineral in this deposit is bertrandite, a hydrous beryllium silicate. Several million tons of bertrandite ore have been identified in as many as eight separate orebodies, with an average grade of 0.60 percent to 0.70 percent BeO. Both the beryllium and associated uranium ore minerals are submicroscopic and are found concentrated in fluorite nodules. Uranium occurs only in the upper half of the beryllium-bearing tuffs, and extends upward into the overlying altered rhyolite flow rock.

Ore processing begins with fine-grinding and sulfuric acid leaching under high temperatures. Solids are removed from the pregnant solution in the counter-current decantation (CCD) circuit, and the solution then travels through the solvant extraction circuit which separates beryllium, uranium, iron, aluminum and fluoride from other elements. Beryllium is dissolved in a special organic solution added to the mixture, which is then stripped of beryllium and filtered. The filtrate contains the uranium, which can be recovered by conventional precipitation methods, or can be sent directly to solar ponds for storage and subsequent recovery. Uranium extraction began in 1981, and through 1982 the operators produced about 35,000 pounds of U_3O_8. The uranium circuit has been shut down since early 1983.

Rare Earths — Uranium is a potential by-product in the production of rare earth minerals. The ores often originate from diverse sources and contain a wide variety of minerals belonging primarily to the columbate and tantalate groups,

© NUEXCO 1987

many of which contain small quantities of uranium. Uranium extraction may even be required to produce acceptable purity in the primary products columbium and tantalum, and to produce clean tailings. The quantities processed are usually small because requirements for rare earths are limited by competition and specialized demand. By-product uranium production from rare earth recovery projects in the USA totaled less than 30,000 pounds in 1986. Producers in India have been actively engaged in research to recover uranium from several rare earths deposits, but production in other countries, if any, is unknown.

Black Shales — Uranium has not been produced from black shales on a commercial basis. Considerable research and development has been committed to uranium-bearing shales, but economically competitive recovery technology does not yet exist. Worldwide, black shales are uraniferous; however, only the Ranstad deposit in Sweden and the Chattanooga Shale deposit in the east-central USA have been evaluated in detail. Both deposits contain many millions of tonnes of uranium-bearing shale that have some potential for recovery of uranium and associated minerals.

Uranium concentration averages 300 ppm in an upper layer of the Ranstad Shale Formation of Cambrian-Silurian age. Estimates place the deposit's mineable U_3O_8 potential at approximately 660 million pounds (300,000 tonnes). A pilot mine and processing plant with an annual capacity of over 250,000 pounds U_3O_8 were built in the early 1960s and operated until 1969. It has since operated as a research facility, investigating recovery of uranium and several other potentially valuable constituents, including kerogen and pyrite. The uranium extraction process includes acid leach, ion exchange and solvent extraction, stripping by the addition of sodium carbonate, and precipitation with sodium hydroxide to produce sodium uranate. Operation of a commercial-scale facility at Ranstad would require a sharp increase in uranium prices and demand.

The Chattanooga Shale is a marine deposit of Devonian age that occupies all of central Tennessee, extending northward into Kentucky and southward into Alabama. In 1944, the US Geological Survey first evaluated the Chattanooga Shale as a low-grade uranium resource. Results indicated a potential uranium resource of about 4.5 million tonnes U_3O_8. The Atomic Energy Commission (AEC) initiated a second study in 1947, covering an area of approximately 35,000 square miles. The US Department of Energy (DOE) also directed a further evaluation of the shale, covering a select area of about 3,000 square miles along the Eastern Highland Rim in Dekalb County, Tennessee.

The DOE study included experimental laboratory procedures to recover as many minerals as possible, including oil, and to establish the technical and economic feasibility of commercial production on a scale of 33,000 tonnes per day produced by underground mining methods. The uranium content of the Chattanooga Shale varies from 55 to 65 ppm. In addition, it contains important concentrations of vanadium, cobalt, nickel, molybdenum, thorium, and the oil constituent kerogen. By 1978, when the study was completed, available technology could recover uranium, syncrude, ammonia and sulfur from the shale, but not the other minerals. The project proved uneconomic at likely recovery prices for the primary minerals contained in the shale.

The study ended with recommendations for a five year experimental mining and extraction program, leading to a full-scale commercial project within 20 years. Experimental development of the Chattanooga Shale is stalled by limited demand for the deposit's recoverable minerals, and serious environmental problems attending such a high-volume mining and processing operation that would be located in a relatively highly populated and developed area.

Seawater — Seawater contains an average uranium content of 3 to 4 ppb (parts per billion). Studies investigating possible recovery of uranium from seawater began in England during the early 1960s, but initially showed recovery costs exceeding $1,200 per pound U_3O_8. Research and development has continued in England and Japan, and more recently, recovery costs of approximately $300 per pound were foreseen. The US DOE sponsored a feasibility study conducted by Exxon and Oregon State University in 1978 which concluded that uranium extraction from seawater was not economically feasible in the USA. Currently, the Metal Mining Agency of Japan is involved in a pilot plant study at Nio, on Seto Island to extract uranium from seawater. The study is scheduled to be concluded in late 1987.

The basic technology for uranium recovery from seawater includes exposure of seawater to a mix of hydrous titanium oxide and other select oxihydrates. Uranium is adsorbed by the mix and in turn is eluted with an ammonium carbonate, or sodium bicarbonate and sodium carbonate solutions. Precipitation can take place by heating the uranium-rich ammonium solution or by the addition of sodium hydroxide to the sodium solutions. Recovery of uranium from seawater currently does not appear practical without a drastic improvement in extraction technology or tremendous increases in uranium prices, or both.

© NUEXCO 1987

Conclusion

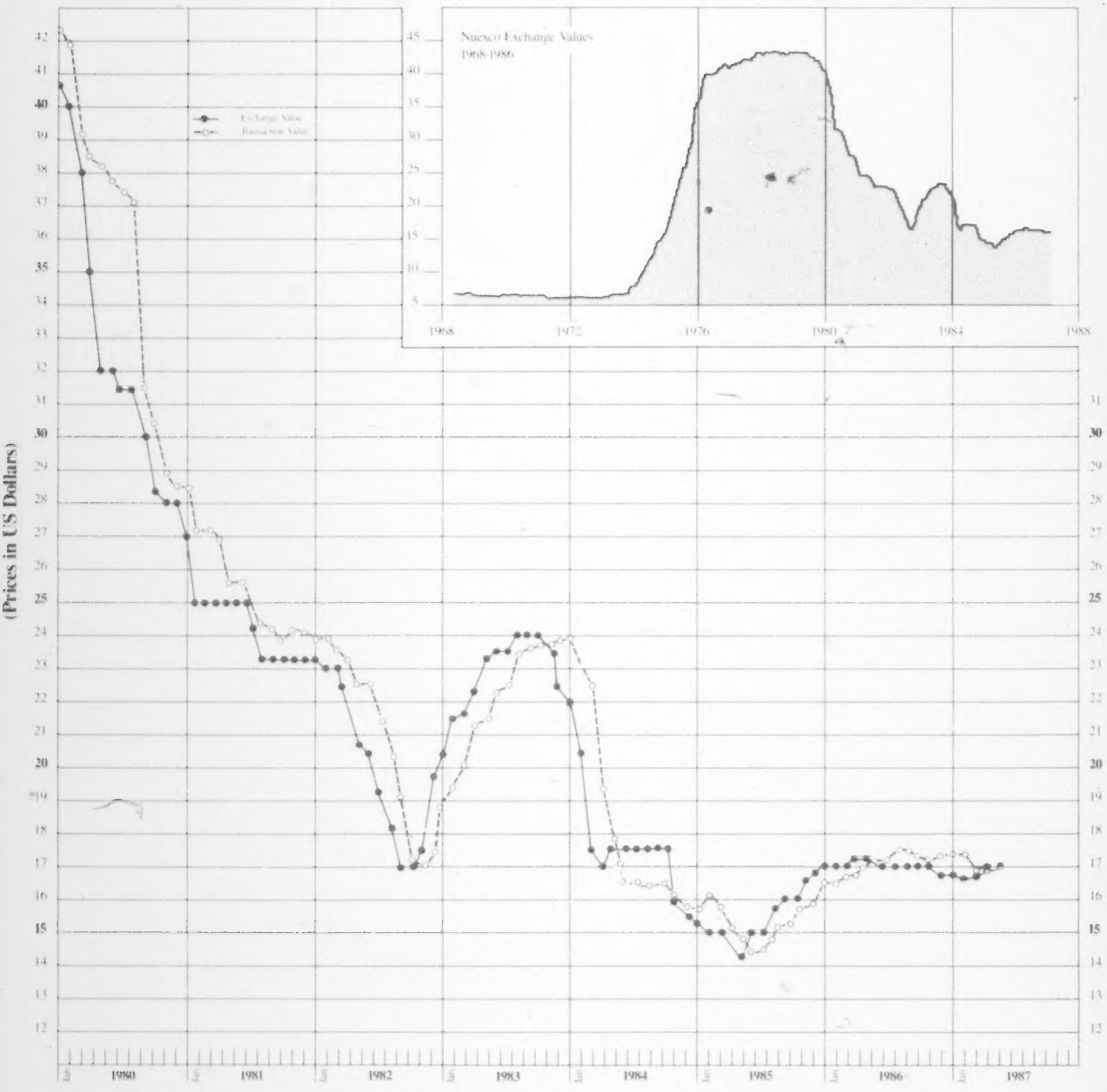
Suppliers of uranium from major by-product producing operations will likely continue to produce at approximately current levels, and production from Olympic Dam represents the only significant increase expected from co-product sources. The combined production of by-product and co-product uranium from all sources will continue to be an integral part of total world production.

Based on uranium price forecasts and the lack of economically viable recovery technology, Nuexco does not expect renewed production from minor sources or new production from potential sources in the near future, perhaps not within the next 15-20 years. Commercial recovery technology does not exist for the large low-grade resources (black shales) and recent research is mainly directed toward one area — uranium from seawater. Only a drastic change in overall industry supply and demand could create the impetus for commercial-scale production from either source.

© NUEXCO 1987

NUEXCO

HISTORICAL MARKET DATA



©NUEXCO 1987

HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	16.75	17.00	**17.00**								

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.60	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.15	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	16.90	16.95	**17.00**								

© NUEXCO 1987

NUEXCO

HISTORICAL MARKET DATA

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated (US Dollars/lb. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.00	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.80	1.90	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	1.80	1.80	**1.80**								

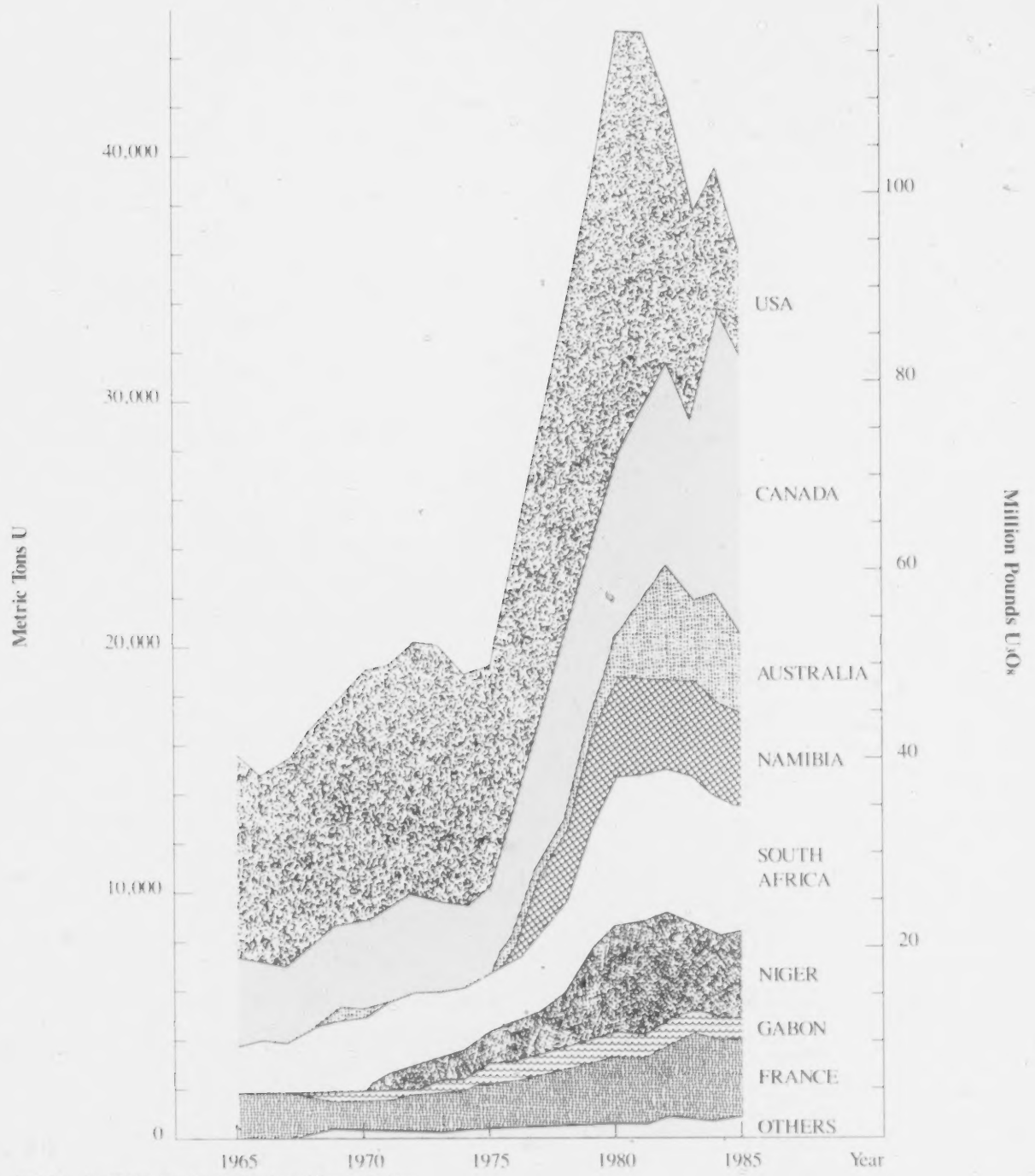
HISTORICAL UF_6 VALUES

Determined as of the last day of the month indicated (US Dollars/kg. U in UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	48.00	48.00	**48.00**								

©NUEXCO 1987

HISTORICAL WOCA[1] URANIUM PRODUCTION[2]
(Compiled by OECD/IAEA Joint Report[3])



[1]WOCA – World Outside of Centrally-planned Economic Areas.
[2]1985 production data are preliminary.
[3]A joint report issued biennially by the OECD Nuclear Energy Agency and the International Atomic Energy Agency.

© NUEXCO 1987

NUEXCO

HISTORICAL MARKET DATA

US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium ($/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium ($/lb. U_3O_8)	Quantity of Uranium Exported (millic .a pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	$28.15[5]	3.6	$43.10	5.8
1981	38.5	32.6[5]	$34.65[5]	6.6	$32.90	4.4
1982	26.9	27.1	$38.37	17.1	$27.23[6]	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3

[1]Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Resources and Enrichment, *Survey of United States Uranium Marketing Activity*, DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, Assistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Uranium Marketing Activity*, DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Uranium Marketing Activity*, DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Uranium Marketing Activity 1983*, DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[2]Sources: 1976-1982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry*, GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3]Excludes direct imports by domestic utilities.

[4]Includes imports by domestic utilities and domestic suppliers.

[5]Includes delivery commitments to domestic utilities and agents.

[6]Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

© NUEXCO 1987

VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]
(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (in MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3,4]		Spot Contracts[3,4]	
			Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8	Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00

[1]The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EC.

[2]The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3]For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar.

[4]Exchange rates as published by European Communities Statistical Office and the International Monetary Fund.

© NUEXCO 1987

NUEXCO

GOVERNMENT STATISTICS

AUSTRALIA

	Consumer Price Index[1]	Price Index of Materials Used in Manufacturing Industry — All Groups[2] (1984 = 100)	Award Rates of Pay Indexes Australia — Adult Males In Mining Wage Earners, Weekly Rates[3] (1975 = 100)
1975 Avg.	57.9	150.4	132.6
1976 Avg.	65.7	168.4	160.9
1977 Avg.	73.8	192.0	179.0
1978 Avg.[4,5]	79.7	198.5	190.0
1979 Avg.	86.9	248.8	127.9
1980 Avg.	95.8	321.8	140.8
1981 Avg.	105.0	355.3	154.1
1982 Avg.[6]	116.7	368.6	174.9
1983 Avg.	128.5	401.6	181.8
FY84 Avg.[7]	133.6	95.3	—
FY85 Avg.[7]	133.6	100.0	—
FY86 Avg.[7]	—	105.0	—
Jan 1986		109.6	210.0
Feb 1986		108.7	210.0
Mar 1986	150.5	99.5	210.5
Apr 1986		94.3	210.5
May 1986		93.5	210.5
Jun 1986	153.0	95.7	210.5
Jul 1986		98.1	215.3
Aug 1986		98.2	215.3
Sep 1986	157.0	105.6	215.3
Oct 1986		106.2	215.4
Nov 1986		105.2	215.6
Dec 1986		105.5	215.6
Jan 1987	—	106.4	215.9R
Feb 1987	—	—	216.5

P = Preliminary R = Revised since last month

[1]Weighted average of six State capital cities (1975 to 1980), and eight capital cities from 1981 (Base: year 1980-81 = 100.0). Index periods are for normal calendar years; figures shown at end of year represent yearly average; figures shown at end of quarter represent quarterly average.

[2]Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0). The basis of this index was revised to 1984 = 100. The previous index was 1969 = 100.

[3]Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.

[4]Monthly data for 1970-78 appear on pages 4.7 and 4.8 of Report 138.

[5]Annual averages prior to 1979 reflect index base no longer in use.

[6]Monthly data for 1979-82 appear on page 35 of Report 184.

[7]Annual averages are for financial year ending June 30.

© NUEXCO 1987

CANADA

	Industry Selling Price Index: All Commodities[1] (1981 = 100)	Wage-earner Data: Average Hourly Earnings (C$)[2]					
		Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Primary Non-ferrous Metal Industries[4] (SIC 296)	(SIC 298)	Chemicals and Chemical Products[5] (SIC 372-379)
1979 Avg.[6]	217.9	—	9.60	9.66	—	—	7.67
1980 Avg.	247.2	—	10.58	10.80	—	—	8.50
1981 Avg.	288.7	—	12.02	12.23	—	—	9.53
1982 Avg.[7]	288.8	—	13.74	13.92	—	—	10.63
1983 Avg.	298.8	—	—	14.30	—	—	11.17
1984 Avg.	310.9	17.88	—	15.07	12.28	10.49	11.76
Jan 1985	117.5	18.05	16.13	15.60	12.32	10.80	12.04
Feb 1985	117.7	18.78	16.41	15.68	12.52	11.05	12.06
Mar 1985	118.4	18.24	16.21	15.57	12.44	10.97	12.02
Apr 1985	118.3	18.63	16.44	15.80	12.81	11.23	12.04
May 1985	118.6	19.41	16.51	15.63	12.76	11.25	12.15
Jun 1985	118.6	18.49	16.20	15.49	12.89	11.14	12.14
Jul 1985	118.6	18.14	16.27	15.41	12.96	11.17	12.13
Aug 1985	118.4	17.07	16.03	15.30	12.97	11.31	12.19
Sep 1985	118.6	18.53	16.55	15.72	12.95	11.39	12.26
Oct 1985	119.0	18.74	16.51	15.70	13.14	11.53	12.33
Nov 1985	119.3	19.05	16.66	15.88	12.76	11.32	12.49
Dec 1985	120.0	19.07	16.57	16.01	12.51	11.09	12.59
Jan 1986	121.0	18.15	16.22	15.86	13.11	11.48	12.52
Feb 1986	120.8	19.52	16.57	15.99	13.20	11.59	12.45
Mar 1986	120.1	19.04	16.65	15.93	13.11	11.59	12.54
Apr 1986	119.3	19.38	16.68	15.95	13.07	11.64	12.54
May 1986	118.4	19.54	16.68	15.78	13.16	11.72	12.51
Jun 1986	118.6	19.80	16.63	15.64	13.44	11.86	12.49
Jul 1986	118.8	19.51	16.34	15.48	13.28	11.73	12.52
Aug 1986	119.1R	18.39	16.17	15.46	13.31	11.31	12.70
Sep 1986	119.4	19.32	16.62	15.78	13.14	11.45	12.90
Oct 1986	119.9	19.97	16.81	16.11	13.30	11.59	12.94
Nov 1986	119.9	20.11	17.01	16.24	13.42	11.66	12.93
Dec 1986	119.7	19.67	16.79R	16.19	13.06	11.57	12.99
Jan 1987	120.0R	19.52P	16.79P	16.11P	12.90P	12.54P	12.89P
Feb 1987	119.8P	—	—	—	—	—	—

P = Preliminary R = Revised since last month

[1]Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Index prior to 1985, 1971 = 100.

[2]Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours" (Catalogue 72-002).

[3]Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

[4]Beginning with the April 1983 figure, Primary Metal Industries, non-ferrous is split into SIC 296 and SIC 298.

[5]Chemical and Chemical Products prior to April 1983 was SIC 370-379. The new series is from a new survey which includes all companies and is based on a 1970 classification. The old survey only included companies of 20 employees or more.

[6]Monthly ISPI for 1977 and 1978 appear on page 4-10 of Report 138, and monthly wage-earner data for 1973-78 appear on page 4-11 of Report 138.

[7]Monthly data for 1979-1982 appear on page 37 of Report 184. On that page, the wage earner index entitled "Metal Mining, Including Milling (SIC 050-099)" should read "Total Mining (SIC 051-099)."

[8]Beginning with the March 1983 figure, Wage Earner Data are based on a census of all companies employing 200 or more wage earners, *plus* a random survey of companies employing fewer than 200 wage earners. Prior to March 1983 only companies employing 200 or more wage earners are included in the Wage Earner Data.

© NUEXCO 1987

NUEXCO

GOVERNMENT STATISTICS

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1980 = 100)[4]	Producer Price Index All Groups[5] (1980 = 100)	Total Employment in Mining and Quarrying (Code 35)[6]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand) (Code 40)[6]
1975	Avg.	16.71	—	157.2	100.0	639,473	1,003,617
1976	Avg.	19.30	—	174.7	115.1	671,240	1,212,983
1977	Avg.	23.87	—	194.4	130.0	712,006	1,420,670
1978	Avg.	27.14	—	137.2	142.7	664,571	1,537,169
1979	Avg.[7]	30.18	—	155.3	164.5	692,209	1,830,632
1980	Avg.[8]	35.53	—	176.7	192.1	714,379	2,279,615
1981	Avg.	41.89	—	206.5	218.3	728,506	2,820,505
1982	Avg.[9]	47.25	104.2	233.5	248.7	707,552	3,246,071
1983	Avg.	51.87	115.0	262.2	274.8	696,579	3,644,772
1984	Avg.	58.95	130.3	292.8	297.9	712,080	4,196,764
1985	Avg.	68.70	151.68	192.6	181.2	726,804	396,956
Jan	1986	—	—	213.8	203.6	744,070	449,513
Feb	1986	—	—	215.8	206.9	754,458	438,562
Mar	1986	75.76	167.8	218.3	206.9	759,897	445,387
Apr	1986	—	—	222.2	208.9	756,388	437,563
May	1986	—	—	222.6	212.5	754,788	425,544
Jun	1986	77.65	172.0	224.4	213.3	756,637	462,365
Jul	1986	—	—	228.8	216.3	756,140	516,832
Aug	1986	—	—	232.2	220.3	760,929	502,968
Sep	1986	81.94	181.8	236.7	221.9	765,772	511,363
Oct	1986	—	—	239.3	226.8	763,953	512,897
Nov	1986	—	—	242.4	230.2	761,325	531,509
Dec	1986	85.38	189.9	244.9	232.1	752,264	536,970
Jan	1987	—	—	248.3	233.9	—	—
Feb	1987	—	—	251.0	237.0	—	—

P = Preliminary R = Revised since last month

[1]Chamber of Mines of South Africa, Johannesburg: "Analysis of Working Results," published quarterly.
[2]Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.
[3]Republic of South Africa Department of Statistics, Pretoria: "Government Gazette: Consumer Price Index for Urban Areas."
[4]The basis for calculation prior to January 1985, 1975 = 100. For annual averages prior to 1978, April 1970 = 100.
[5]Previously known as the Wholesale Price Index, now the Producer Price Index. The computation remains the same. The basis for calculation prior to January 1985, 1975 = 100.
[6]Bulletin of Statistics, Department of Statistics, Pretoria.
[7]Historical data for the Average Declared Working Costs and Consumer Price Index 1970-1979 appear on page 4.9 of Report 140.
[8]Monthly data for Codes 35 and 40, 1977-1980, appear on page 28 of Report 157.
[9]Monthly data for 1979-82 appear on page 39 of Report 184.

©NUEXCO 1987

UNITED STATES

	Producer Price Index[1]		Consumer Price Index[2]	GNP Implicit Price Deflator[3,4]	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[5]			
	Industrial Commodities (1967 = 100)	All Commodities (1967 = 100)	(1967 = 100)	(1982 = 100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980 Avg.[6]	274.8	268.8	246.8	178.64	10.26	10.63	8.30	6.94
1981 Avg.	304.1	293.4	272.4	195.51	11.55	11.98	9.12	7.62
1982 Avg.[7]	312.3	299.3	289.1	207.15	12.33	12.94	9.96	8.21
1983 Avg.	315.8	303.1	298.4	215.63	12.57	13.43	10.59	8.65
1984 Avg.	322.6	310.3	311.1	108.1	13.05	13.43	11.08	9.04
1985 Avg.	323.9	308.8	322.2	111.7	13.39	13.75	11.56	9.47
Jan 1986	323.8	308.9	328.4	—	13.40	13.69	11.86	9.60
Feb 1986	318.9	304.4	327.5	—	13.44	13.82	11.81	9.60
Mar 1986	314.0	300.3	326.0	113.5	13.38	13.93	11.78	9.62
Apr 1986	311.6	298.2	325.3	—	13.54	13.87	11.82	9.62
May 1986	311.6	299.2	326.3	—	13.46	13.79	11.89	9.64
Jun 1986	311.8	299.0	327.9	114.2	13.52	13.49	11.94	9.61
Jul 1986	308.5	297.4	328.0	—	13.47	13.22	12.04	9.68
Aug 1986	307.9	297.2	328.6	—	13.04	13.18	11.99	9.67
Sep 1986	308.7	297.5	330.2	115.0	13.11	13.41	12.03	9.73
Oct 1986	309.6	298.4	330.5	—	12.51	13.29	12.08	9.72
Nov 1986	309.8	298.7	330.8	—	12.57	13.27	12.15	9.75
Dec 1986	309.3	298.1	331.1	115.3	12.70	13.16	12.20	9.85
Jan 1987	313.6	300.9	333.1	—	12.80R	13.10R	12.17R	9.86R
Feb 1987	315.7	302.7	334.4	—	12.79P	12.96P	12.20P	9.87P
Mar 1987	315.8	302.8	335.9	116.2	—	—	12.26P	9.86P

P = Preliminary R = Revised since last month

[1]US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents.

[2]US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items.

[3]US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted.

[4]The basis for calculation of this index was revised to 1982 = 100. 1984 and 1985 figures have been adjusted to that basis. The basis for calculation prior to 1984, 1972 = 100.

[5]US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Data for 1970-1976 are adjusted to the March 1977 benchmark. Data for 1977-1978 are adjusted to the March 1979 benchmark. Data for January 1979 and beyond are adjusted to the March 1980 benchmark.

[6]Monthly data 1970-1978 for Producer Price Index-Industrial Commodities, Consumer Price Index, and Employment and Earnings SIC codes 10, 333, and 28, and quarterly data for GNP Implicit Price Deflator appear on pages 4.6-4.8 of Report 139.
Monthly data 1977-1978 for Employment and Earnings SIC Codes 10, 333, and 28 appear on page 33 of Report 147.
Monthly data 1970-1978 for Employment and Earnings SIC Code 36 appear on page 23 of Report 154.
Monthly data 1977-1980 for Producer Price Index-All Commodities, appear on page 21 of Nuexco Report 158.

[7]Monthly data 1979-1982 for all listed indices appear on page 41 of Report 184.

©NUEXCO 1987

NUEXCO

SERVICE LOCATIONS

DENVER, COLORADO, USA
Earl E. Hoellen, Jr.

Three Park Central
1515 Arapahoe Street
Suite 900
Denver, Colorado 80202
Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 (NUEXCO DVR)

MENLO PARK, CALIFORNIA, USA
George White, Jr.

Bldg. i, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO)

FERNEY-VOLTAIRE, FRANCE
James E. Vaughan

13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

ZURICH, SWITZERLAND
Donald P. Ebright

135 Zürichstrasse
CH-8700 Küsnacht
Switzerland
Telephone: (41-01) 910-9877
Telecopy: (41-01) 910-6672
Telex: 58877 (COMAG)

TOKYO, JAPAN
Christian C. Guitton

Ohkura Building
1-4-10 Shiba Daimon
Minato-Ku, Tokyo, Japan
Telephone: (81-3) 431-6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

REPRESENTATIVES

AUSTRALIA **James G. Munro**
7 Nevada Street
North Balwyn, Victoria 3104
Australia
Telephone: (61-3) 857-6823
Telecopy: (61-3) 857-8258

SOUTH AFRICA **Chris I. Von Christierson**
Southern Prospecting (Pty) Limited

Mailing Address
P.O. Box 61409
Marshalltown 2107
Republic of South Africa

Street Address
10th Floor
Eagle Star House
70 Fox Street
Johannesburg 2001

Telephone: (27-11) 838-1868
(27-11) 834-4211
Telecopy: (27-11) 834-3148
Telex: 4-89878-SA

UNITED STATES **Harold C. Lindberg**
83-A Hardee Lane
Whispering Pines, N.C. 28327
Telephone: (919) 949-3622

JAPAN **Kazy Yokota**
Japan Tech Services
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

TAIWAN **Edward Bee**
Bee & Liang Company, Ltd.
14 FL Universal Business Center
NO. 663, Tun Hwa South Road
P.O. Box 1396
Taipei, Taiwan R.O.C.
Telephone: (886-2) 704-9630
Telecopy: (886-2) 703-4625
TWX 785-11570 (BEELIANG)

UNITED STATES **Ralph O. Smith**
141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 271-1346